PREFACE

This document is a summary of over 3 years of work by various agencies and individuals. The sheer size of the document is an indication of the enormous amount of time and effort that has been expended to date. The size can also create a strong reluctance to read and evaluate the entire content. The document structure is intended to allow the reader to obtain a AS MUCH knowledge about the system plan as he is willing to read. The Executive Summary in section 1 is a very brief overview of the plan. Sections 2 - 10 provide detailed explanations and information about the plan. The remaining sections provide additional information to further increase the readers overall knowledge of the system requirements and operations.

1.0 EXECUTIVE SUMMARY

Telecommunications has been rapidly evolving over the past 5 years. The migration to digital technology in a wireless environment has been a focal point of business, industry and government. The National Information Infrastructure (NII) or information super highway initiative is the best example of this. The State of Colorado is ready to play an important role in how government will plan, implement and use a statewide network. This plan is already being looked upon by the federal government, other states and local government agencies as the model for access to the information super highway. Colorado is very fortunate to have a lead telecommunications agency that can provide the expertise to all levels of government. The spirit of cooperation between the user agencies and the Division of Telecommunications is unprecedented and has been a key factor in the development of this plan.

This planning effort began in 1991 as a result of a Joint Budget Committee footnote and legislative audit. The Division of Telecommunications in cooperation with the State Patrol developed a conceptual idea on what a new wireless telecommunications network would look like. The concept looked at the various technologies and strategies. Once the concept was documented, it was both necessary and important to explain the concept to existing and potential users of the new system. Many meetings were held to introduce the concept and seek input in the further development of the concept. The initial concept also included a requirement that any new system must be based on the needs of the users first and foremost. There is an abundance of technology available, but if it doesn't function to the user needs, the technology becomes a worthless "pile of junk".

One of the first requirements was to carefully examine the existing systems for positive and negative features. There were several common problems including poor or inadequate interoperability with other agencies, poor coverage areas and no data or document capability. Any new network would need to address these specific areas.

In order to truly develop this plan based on the user needs, a statewide users group was formed to identify what the exact needs were. The group met for 8 months and has developed a full set of system operational requirements. It will not be possible to meet the entire set of requirements, they do define basic, advanced and future users needs. The work of the users group will be an invaluable tool in final system development.

Another major factor in the planning efforts are anticipated changes of existing FCC rules. The FCC has initiated a complete re-write of the rules for all frequencies below 800 MHz and above 50 MHz. This re-write is commonly referred to as "Part 88". The proposed changes in Part 88 include allowing trunking in the VHF band, splitting channels to create more channels and limitations on transmitter power. The most notable affect of Part 88 will require the complete replacement of all radio equipment currently in use by state and

local government agencies. There will be an extended time frame to allow for amortization of the existing equipment. The exact time frame and final rules are expected to be released in the spring of 1995. Frequencies in the 800 MHz band are not affected by Part 88.

Two technologies have been selected as the basis for the network implementation. The first is trunking and the second is digital transmission. Trunking is not a new technology but when combined with digital transmission can provide a high capacity wireless network for voice, data and images. Trunking allows a single system to be shared by all users. This eliminates the redundant systems currently in operation. The new digital trunking system will be built using a set of open standards. These standards will further improve the ability to share the system for all levels of government and prevent the problems encountered with proprietary systems.

The ability to share the system by state, local and federal agencies at various levels will allow the users to meet their own needs without having to go beyond their own financial resources or not be able to meet their own requirements. A flexible participation schedule has been developed to achieve this feature.

The legislative requirement for the State Patrol to reduce the number of existing communications centers has been an integral part of this effort. The technologies and architecture chosen will allow this requirement to be easily implemented as part of the system. It will require several common system elements to achieve this for both technical and financial reasons.

As with any new technology, one of the biggest concerns is how much does it cost and where will the money come from, this is especially true at all levels of government. Initial cost estimates ranged from 50 to 60 million dollars. Current estimates now range from 100 to 120 million dollars. Until a final technical design is complete and the network vendor selected it will be very difficult to provide more exact figures. Current estimates for mobile and portable radios range from $2,000 to $2,800 for high tier models. The users group has already begun studying various sources of funding. All potential funding resources will be explored. There are many federal programs available including NII grants, NTIA grants, drug interdiction and crime programs. Federal agency participation may provide additional funding sources. The State will have to fund its share of the system.

A 6 year implementation schedule beginning in fiscal year 1996/1997 has been developed to allow the funding to be broken into yearly installments. The 6 year schedule does not exceed the Division of Telecommunications ability to design and implement the system. Actual implementation is contingent on funding.

IMPLEMENTATION SCHEDULE

Phase 1 - Denver Metro Area	July 1996 - June 1997
Phase 2 - Northeast Colorado	July 1997 - June 1998
Phase 3 - Southeast Colorado	July 1998 - June 1999
Phase 4 - San Luis Valley	July 1999 - June 2000
Phase 5 - Southwest Colorado	July 2000 - June 2001
Phase 6 - Northwest Colorado	July 2001 - June 2002

Colorado is truly in a unique position to be a leader on the information super highway. Moving forward with this plan will allow government at all levels to meet the ever increasing needs to better serve the public with less. Delaying or failure to implement, will deny the necessary tools for government to provide quality service to its citizens. It will also most likely place government behind the general public in access to the information super highway

2.0 INTRODUCTION

This plan is the culmination of 3 years of research, numerous meetings and dedicated work by the public safety and government communities within the state. This plan will discuss the history, background and direction develop a new statewide system, review of the existing radio systems and the work of the users group in developing the requirements for the new system. It will also discuss the features and benefits of using trunking technology and the advantages that an open standards based system can provide. The management and control of the system will be discussed as well as the availability of shared use by state, local and federal agencies. The final portion of the plan will look at system cost, funding, user fees and system maintenance.

3.0 HISTORY AND BACKGROUND

Colorado state government has been utilizing radio communications since 1948. Initially the primary user was the Colorado State Patrol. In the mid 1950's the Department of Highways and other State agencies began using the State's communications network. These systems operated in the 40 MHz. frequency band and were very inefficient. This era of mobile radio technology communications evolved very slowly compared to today's rapid technological advancements.

In 1971 the Division of Telecommunications was created within the Department of Administration to be the central state agency responsible for the communications systems for State government. Over the years the Division has strived to keep up with the advancements in technology and system improvements. One of the problems is the current systems were developed for different agencies at different times without the ability to integrate the systems into a single statewide network. The technology available also limited the system capabilities.

3.1 FOOTNOTE 7

Part of the Division of Telecommunications ongoing responsibility is research and consideration of new technologies to improve the existing system capabilities and upgrade to newer technology. In the 1991 long bill the Joint Budget Committee included a footnote in the State Patrol's funding. Footnote 7 required the Patrol, along with the Division of Telecommunications and Information Management Commission, to develop a plan to replace and update the current system, This plan should examine the cost-effectiveness of funding the replacement in one payment versus phasing the costs over several years, as well as the costs and benefits of reducing the number of the existing dispatch centers in the state. This plan should address the personal services savings that could be achieved if the state were to consolidate the centers and how these savings could offset the cost of a new system.

3.2 LEGISLATIVE AUDIT

During the regular review of the Division of Telecommunications by the Legislative Audit Committee, the auditors reported; "According to our consultant, the technology is old, costly and inefficient. This public safety network, which supports about 6,700 mobile radios, is based on analog technology, which does not allow interagency communications or sharing of resources." and "Communications for public safety agencies is of great importance. These agencies need reliable, effective equipment. Although a replacement system is costly, we believe the Division should continue to analyze how to improve the public safety two-way radio network."

Footnote 7 and the audit report are the two items that set the course the Division of Telecommunications has taken over the last three years, with the development of this plan as a final result.

3.3 INITIAL CONCEPT

In response to footnote 7 a report was made to the Joint Budget Committee with a conceptual plan to replace the State Patrol radio system with a new digital trunked radio system and consolidate the 17 local communications centers into 5 regional centers. The conceptual plan included replacing all State radio systems with a single statewide network. It was clear that such a large project would require a large scale effort by the State and that the system would support shared use by local government agencies. In the review of the existing systems it was determined that many of the users' needs were not being met. If the State were to implement the new system it had the potential of affecting the current and future plans of all State and local government agencies.

3.4 INFORMATIONAL MEETINGS

The decision was made to inform all public safety agencies as well as current system users, of the State's plan for the future of telecommunications and how new technology could better meet their needs. An informational program was developed in the spring of 1992. The Division of Telecommunications and State Patrol has presented over fifty informational programs to various state agencies, local government agencies, public safety organizations and other interested groups. Many federal agencies attended the programs and became very interested in the possibility of sharing the new statewide system. The Federal Law Enforcement Wireless Users Group (FLEWUG) learned about the efforts in Colorado and sent a representative from Washington to attend one of the informational programs. As a result, the Colorado plan may be used as a model to meet the federal requirements for a nationwide law enforcement network.

One of the functions of the informational meetings was to ask the users to help develop the requirements for the new system. While the Division of Telecommunications has the technical expertise to design the system, it does not have the user expertise to assure that the needs of all potential users are documented and used as the most important criteria in the new system design. The creation of the State Digital Trunked Radio System Users Group was a direct result of the informational meetings. The role of the users group will be detailed later in the plan.

4.0 EXISTING SYSTEMS

In order to develop a new system, it was first necessary to evaluate the existing systems and evaluate both their strengths and weaknesses. The majority of the current systems were designed with 1970's technology and could easily meet the needs of the users then. The evaluation process was based on how the systems are used today, and if they meet the basic needs of the users.

4.1 OPERATIONAL DESCRIPTION

Wide area and local or facility based systems are the two major system types currently in use. Facility and local based systems are those used by the Department of Corrections, Division of Parks and Outdoor Recreation and various colleges and universities. These systems are limited in area of operation to a specific location. Wide area systems are those used by the State Patrol, Department of Transportation and Division of Wildlife. These systems require coverage over a large geographic area varying from a troop, section or region to state wide requirements. The Department of Corrections has a unique requirement for both facility based and wide area systems. Existing system maps are included in appendix 12.7.

Both types of existing systems operate using analog transmission for voice only. Each agency is assigned a channel or channels depending on their requirements. Operations for each agency are conducted on these channel(s) which during peak normal usage and major incident response become over utilized. An agency is restricted to operation on only their own channels. This type of operation is known as "conventional technology".

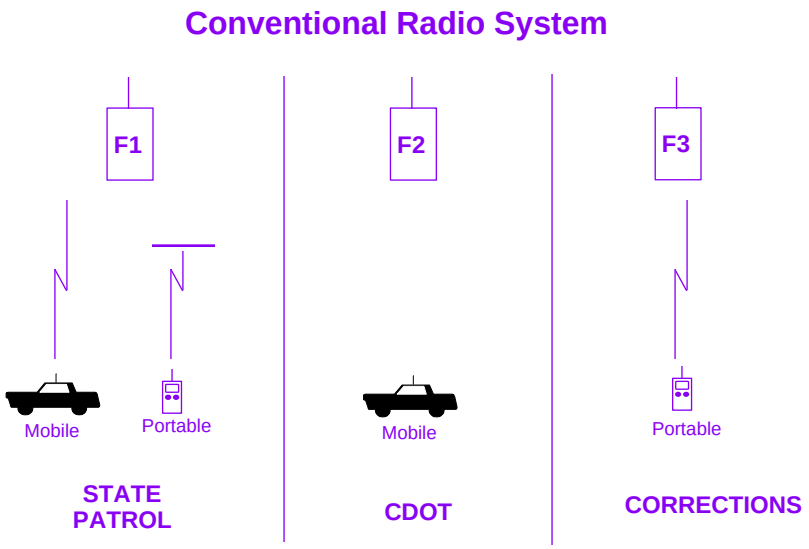


Figure 4. 1

The majority of the technology used in the current systems was developed in the 1970's. This technology severely limits the ability to use the systems for new applications, such as mobile data and automatic vehicle location systems. New equipment has replaced worn out equipment, but the system technology (conventional/analog) has not been changed.

Since the existing systems were developed for each agency during different time frames, many of the systems are redundant and provide the same area of coverage and operational characteristics. This piecemeal implementation process has resulted in many problems including a lack of a true statewide network, limited or no resource sharing, and poor or limited interoperability with other state, local and federal agencies.

While the local and wide area based systems differ in their operational characteristics, wide area systems are just a series of local systems connected via the state microwave network to a local or area communications center. Even the systems that provide state wide coverage are simply a combination of interconnected local area systems. This method of creating wide area systems is again based on old antiquated technology. These old technology based systems require "smart users" and many of the perceived system problems are really a lack of the proper channel for a specific area, the lack of familiarity with the system. (Many of the complaints from the users are placed in this category.)

All of the wide area systems and the majority of the local area systems operate in the 150-160 MHz. range (VHF band). A few of the local area systems operate in the 450- 470 MHz. range (UHF band). A very limited number of systems operate in the 806-869 range (800 MHz. Band). Part 90 of the Federal Communications Commission Rules govern the operation of these systems. These rules also allocate a finite number of frequencies for specific uses. Frequencies are categorized by the type of use including Local Government, Police, Fire, Highway Maintenance, Forestry Conservation and Emergency Medical. The demand for these frequencies has exhausted the allocations and it is virtually impossible to obtain new frequencies along the front range in both the VHF and UHF bands. Sharing of frequencies is a common occurrence and as a result creates system interference to varying degrees. This problem is not unique to Colorado and is even more pronounced in the very heavily populated area in the midwest and east coast. This problem prevents expansion of existing systems and creation of new systems when needed.

All of these characteristics provide the users with fragmented and inadequate networks. Many agencies current requirements cannot be met simply because the old technology limits the ability to meet their communications needs in today's information dependent society.

5.0 USERS GROUP

The experience gained by the Division of Telecommunications in previous communications projects has provided the methodology for the development of this plan. If the system is going to be acceptable to the users and meet their needs, then the users should have a large voice in the planning and design of the system.

During the informational meetings, those in attendance were invited to participate in the Digital Trunked Radio System Users Group. Over 200 people signed up to participate. All members were informed that participation in the group did not commit their agency to use the system, but it would help assure that their agencies needs were addressed.

The Group began meeting in the fall of 1993. Monthly meetings were held until June of 1994. There were approximately 60 people actively participating from various state, local and federal agencies. The group was given the task of developing what a new system would require in order for them to perform their jobs more efficiently and effectively.

5.1 PARTICIPATION

Participation in the group was open to anyone who expressed an interest. The group was fairly even between state and local government agencies with very limited federal representation. The 2 major vendors of trunked radio systems also participated, but were strongly warned that they were not to attempt to sell their system or compete with each other.

The group was asked to develop the operational and system requirements based on their needs and not on what the technology was capable of. In keeping with the basic concept of the whole planning process for the project, the group was instructed to use their imagination and “get outside of the box”. The final requirements described in this plan meet that objective. While not all of the requirements can be achieved with the technology or on a cost effective basis, the majority can be met and the system final design will strive to achieve as many as possible.

5.2 STRUCTURE

In order to thoroughly cover all of the areas within the users group, it was divided into 4 sub-committees. Each committee was asked to develop a strategic plan with a mission statement, goals, objectives, strategies and resources to achieve their goals. The structure of the group is shown in figure 5.2. There is still a great deal of work to be completed by the group in the technical and funding/fees sub-committees. The system and user operational requirements have been well defined. This portion of the plan will be the catalyst for the rest of the system development.

DIGITAL TRUNKED RADIO SYSTEM USER GROUP STRUCTURE

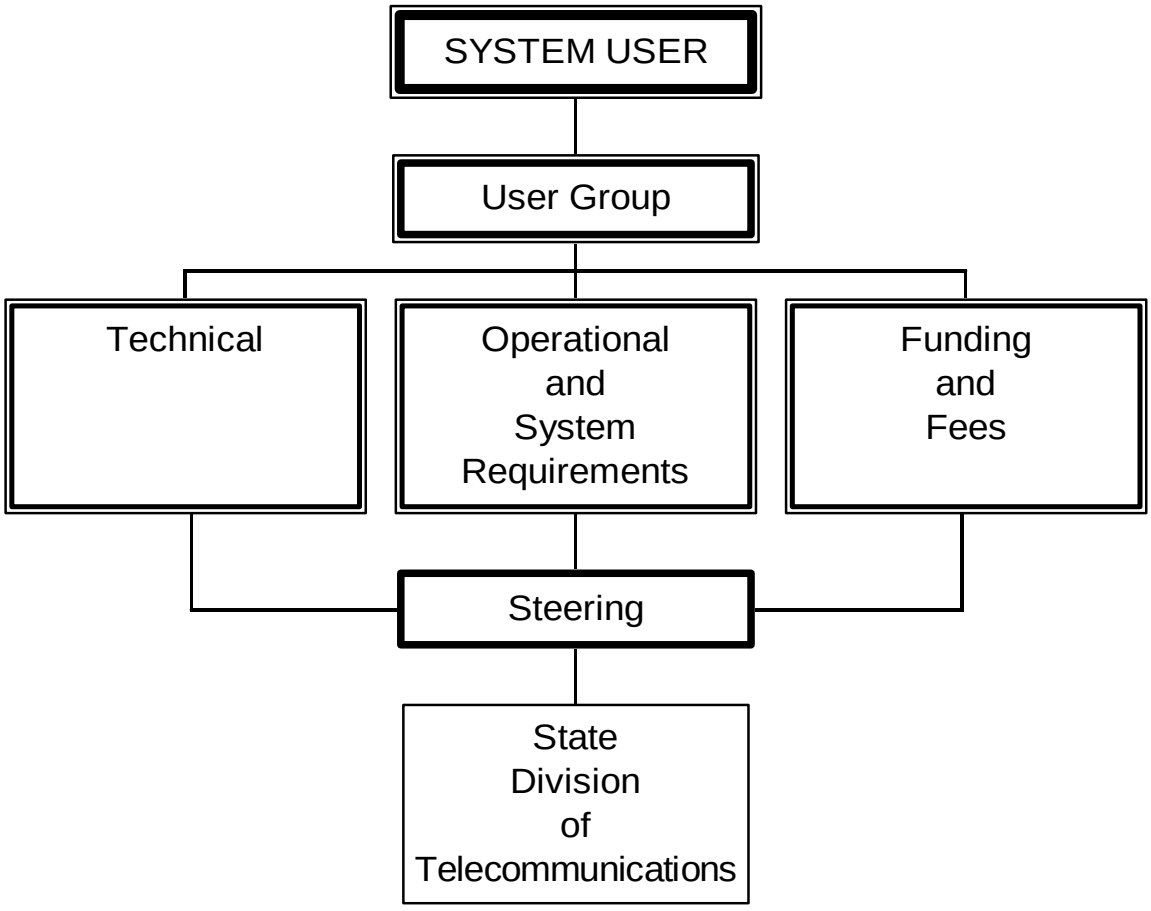


Figure 5. 2

5.3 SYSTEM AND USER OPERATIONAL REQUIREMENTS COMMITTEE

COMMITTEE FOCUS

Determine system requirements, management, structure and maintenance.

KEY ISSUES

1. Management of organizational structure
2. User group definition and span of control
3. Maintenance (user group - infrastructure)
4. Ownership and acquisition of equipment
5. Interfacing with: non-users, users, 800-Vhf
6. Capabilities and deficiencies - technical group

5.4 FUNDING AND FEES COMMITTEE

COMMITTEE FOCUS

Seek funding sources for all user agencies and explore and adopt, if required, user fee structure.

KEY ISSUES

1. Research grant possibilities.
2. Research funding via Anti-Crime Bill.
3. Check funding sources used by other states that have implemented a statewide system.
4. Prepare cost analysis so we know how much money is needed overall infrastructure).
5. Obtain roll out schedule from State.
6. What agencies have equipment or site locations that can be used in lieu of user fees.
7. Explore sources for agency sellbacks of existing equipment.
8. Establish user fee schedule.
9. Provide funding information to potential user agencies.

5.5 TECHNICAL COMMITTEE

COMMITTEE FOCUS

VHF and/or 800

KEY ISSUES

1. Enough VHF Frequencies
2. 800 Mountain coverage
3. Identify frequency needs for each area
4. Option needs for multiple Vhf at one site; IM, Noise
5. Stand alone
6. Migration
7. Private system

5.6 STEERING COMMITTEE

COMMITTEE FOCUS

Manage the process of Planning, Promoting, Implementing the digital trunked radio system of the State of Colorado.

KEY ISSUES

1. Monitor APCO and other standards. (Insure tech committee does this.)
2. Review other committee work and provide direction.
3. What is our role to the Division of Telecommunications?
4. How is the system going to be administered: during planning; after implementation?
5. Set time lines.
6. Identify barriers to implementation of project.
7. Ensure equal affordability of system. Who has grant money available? (Funding Committee)
8. Use short term sub-committees to get projects done.
9. Advise Division of Telecommunications on needs of system.
10. Develop long term system advisory team.

6.0 TRUNKING

The concept of trunking was originally developed by the telephone industry to allow the sharing of long distance telephone circuits. The term trunking means sharing of small number of talk paths (circuits or channels) by a large number of users. Trunking was introduced to radio systems in the late 1970's and a set of required system features and operational requirements for public safety systems was developed by APCO in Project 16 in the early 1980's. Project 16 **did not** include requirements for common architecture or interoperability between different system vendors.

6.1 OPERATIONAL DESCRIPTION

A trunked radio system allows the users to be automatically and dynamically assigned to an available channel within their area of operation. Trunked radio systems offer substantial efficiency over conventional system based on two fundamental principles;

1. The percentage of time that any individual user requires a trunk is very small.
2. The probability that many users will require a trunk at the same instance is exceedingly small.

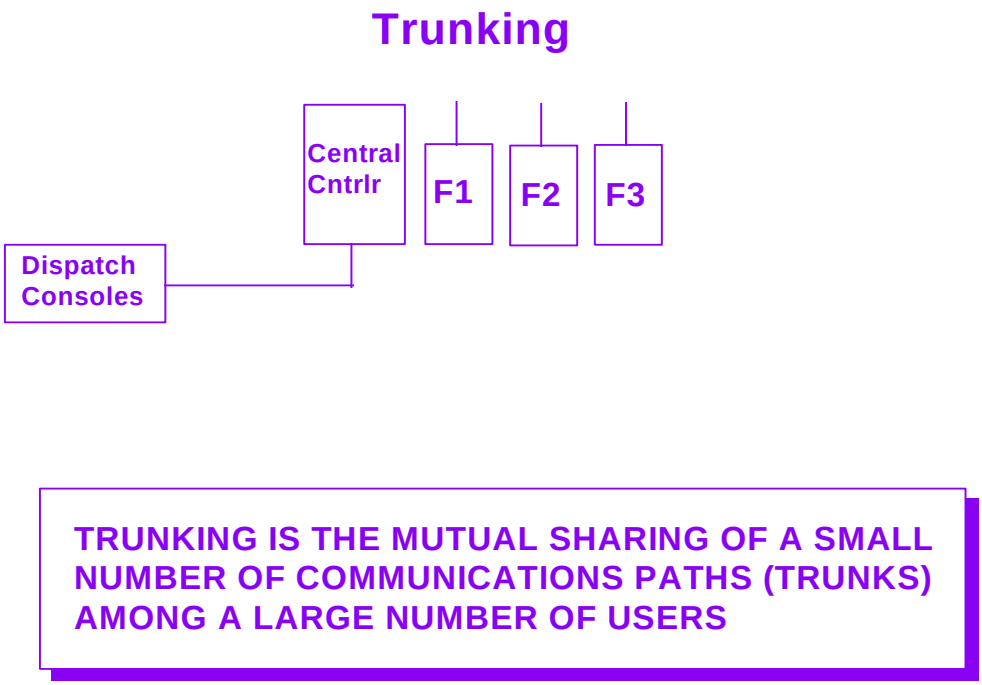
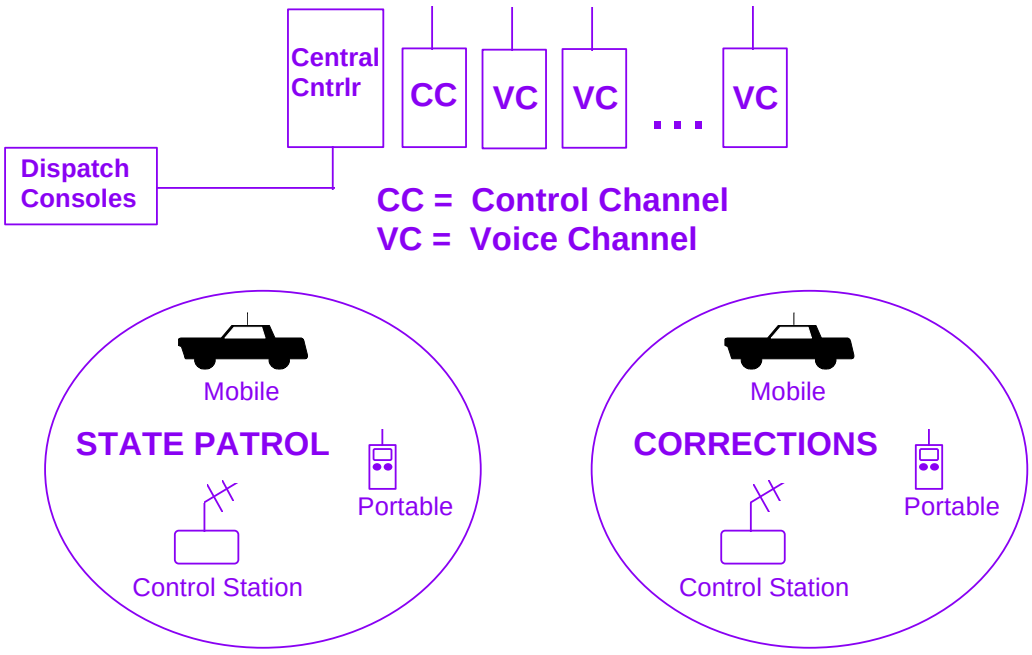


Figure 6. 1

6.1.1 FEATURES AND BENEFITS

The capacity and capabilities of trunked systems are also greatly enhanced by the use of microprocessor chips to control the system and individual radios. The use of specialized software also provides new management capabilities. These components of the system allow trunked system to organize radio users by talk groups rather that by frequencies or channels. This provides the effect of a private channel per talk group and the flexibility to reorganize and expand the system as the need arises.



A *TALKGROUP* is a set of users that normally communicate on a day to day basis

Figure 6. 2

6.1.2 SAMPLE TALK GROUP CONFIGURATION

Using the criteria established by the operational committee the following examples show how talk groups would be configured for a state agency, city or county. These are only examples and each agency would have the ability to organize their talk groups as they choose within the criteria established by the users group.

STATE AGENCY TALK GROUP CONFIGURATION

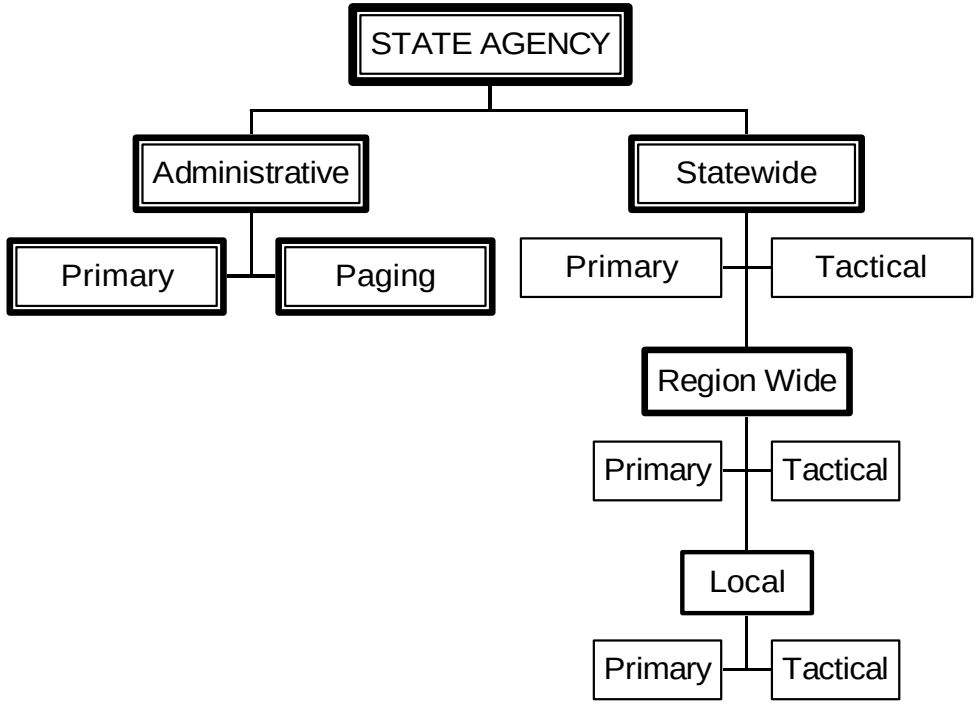


Figure 6. 3

One primary and one tactical talk group would be available for each district or operational function. Talk groups would only be assigned for those functions that actually exist and are necessary to provide effective communications.

LOCAL GOVERNMENT TALK GROUP CONGIGURATION

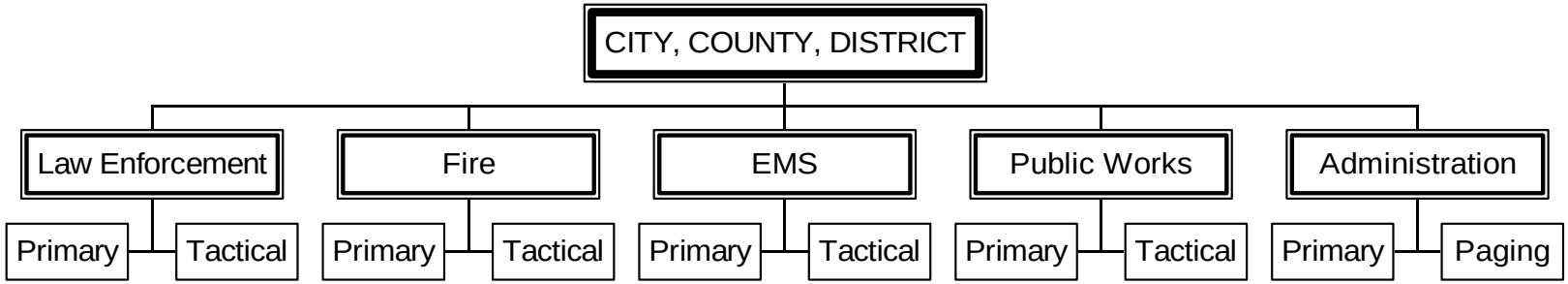


Figure 6. 4

One primary and one tactical talk group would be available for each district or operational function. Talk groups would only be assigned for those functions that actually exist and are necessary to provide effective communications.

TALK GROUP EXAMPLE
COLORADO STATE PATROL

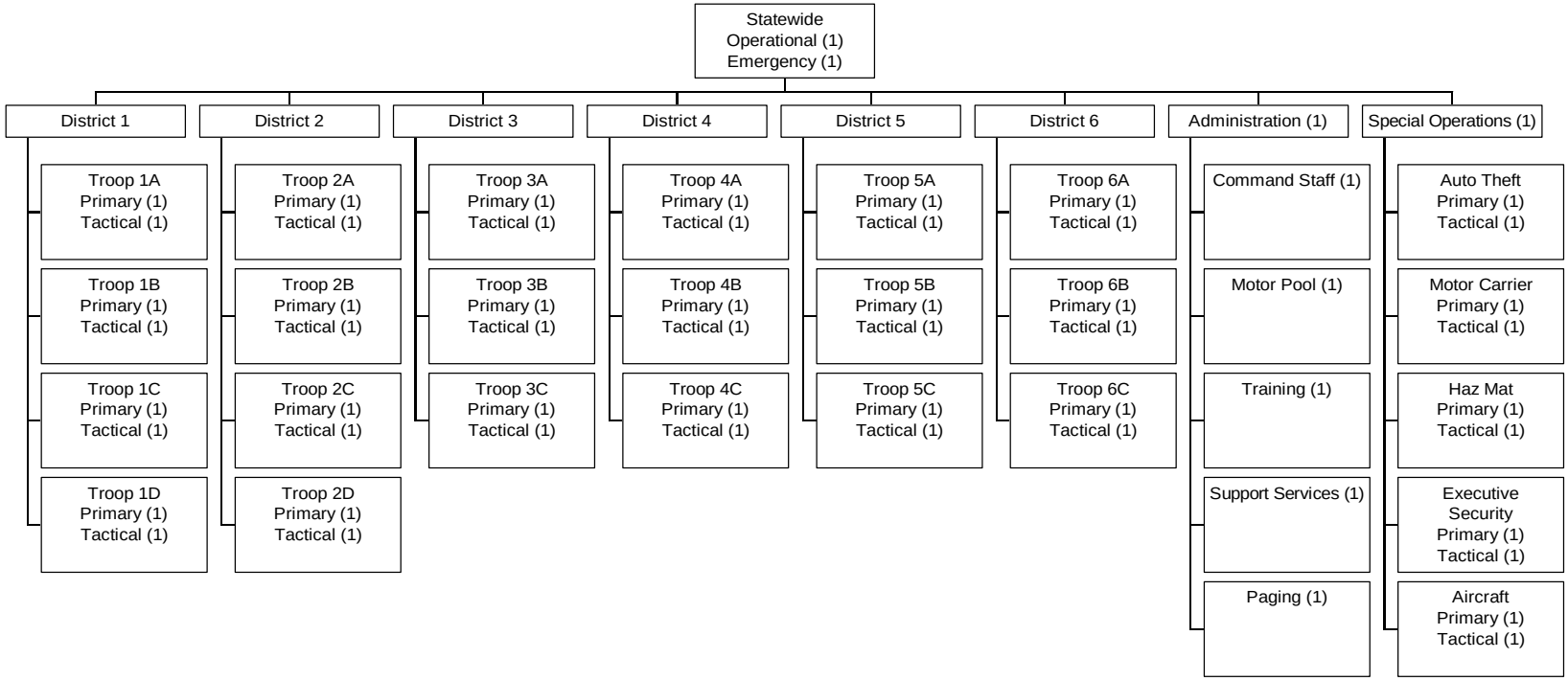


Figure 6. 5

The basic system features and benefits of trunked radio systems include:

Radio User Organization

48,000 Unit ID's - The system is capable of handling a very large number of radios.

Any Number of Units per Talk group - A talk group can be as small as 2 radios or as large as every radio in the system.

4000 Talk groups - The system can provided a very large number of talk paths. Talk groups can be Organized in Any Manner with Virtually Unlimited Levels: Fleets, Agencies, Departments, Districts, etc.

Call Types

Talk group Call - Normal conversation within a common group of users.

Individual Call - an individual users can dial another users and conduct a private. conversation

Emergency Call - By pushing the "Emergency" button on the radio a users can alert the dispatcher immediately and display the ID of the calling unit.

Announcement Group Call - A dispatcher can give an "APB" to several groups simultaneously.

Telephone Interconnect Call - A user can use the radio to make telephone calls within the public telephone system.

Trunking Features and Capabilities

Busy Queuing & Call Back - When all channels become busy the users are placed in a queue according to their priority level and automatically alerted when it is their turn to talk.

Recent User Priority - A user is moved higher in the queue to complete a recent conversation, only when all channels are busy.

Automatic Retry - If a weak signal or interference prevents access to the system, the radio will automatically retry to gain access.

Continuous Assignment Updating - The system will continually update every radio as to the channel assignment and status.

Out of Range Tone - The user is alerted if the radio is out of range of the system.

Unit ID - Each radio transmits a unique ID that can include an alias, which can be the name, call sign or other special identifier of the user.

Priority Access - The system is capable of 7 levels of priority for placement in the queue when all channels are busy. An emergency always has priority 1.

Dynamic Regrouping - Using the system manager a dispatcher can move radio to new talk groups for special activities or emergency operations.

Selective Radio Inhibit - A lost or stolen radio can be remotely disabled, prevent unauthorized access to the system.

Talk group Merge - A dispatcher can merge individual talk groups into 1 group for special activities or emergencies.

Perhaps the 2 greatest benefits of trunking compared to conventional systems are; 1) The ability to share resources among a large number of users. 2) The capability of interoperability when all users are sharing a common system. A state wide system expands these benefits to the State and will allow users to have wide area communications capability, well beyond their current systems. The system will also provide statewide roaming capability for users who travel in all areas of the State. The users group identified the lack of coverage and the lack of interoperability with other agencies as the two biggest deficiencies of their existing systems.

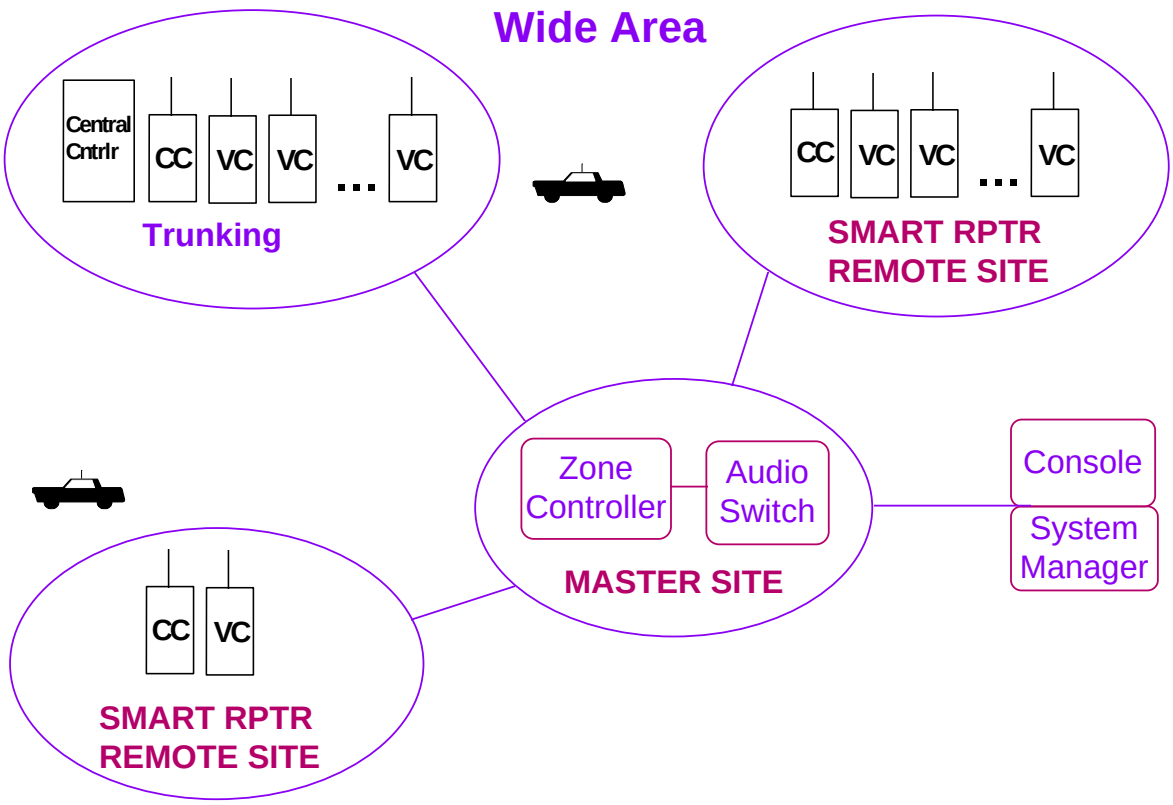


Figure 6. 6

The system also provides the capability for communications to occur across the State. A user in Durango is able to communicate with a user in Sterling simply by utilizing a common talk group, no special setup or user actions are necessary.

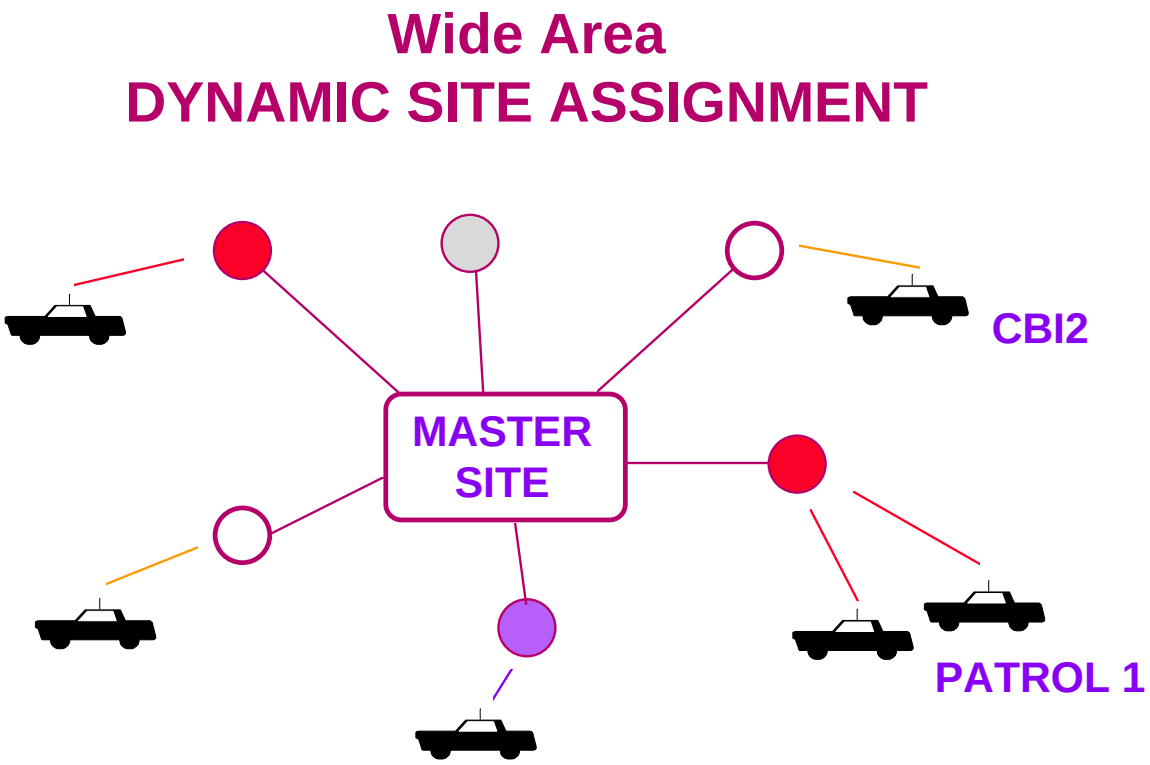


Figure 6. 7

6.2 OPERATIONAL AND SYSTEM REQUIREMENTS

The requirements described in this section have been taken from the users group final reports. This list does not include all the requirements contained in those reports, but includes those the can be achieved within the technology, budget and schedule. While those items not listed are important, they were developed with the concept of no limitations on the technology or cost. The requirements that the system will not initially be capable of will be considered for future enhancements to the system. The entire set of requirements is contained in the sub committee final reports in appendix 12.1.

General System Capabilities

1. System Flexibility
   a. Repeater and Non-repeater operations
   b. Full duplex (simultaneous transmit & receive)
   c. Concurrent Data and Voice capabilities
   d. Easily configured talk groups for intra-agency and inter-agency/multi-jurisdiction operation/coordination
   e. Widely configurable talk groups, some very large, including hundreds or even thousands of units, and some very small.
   f. Local and Wide area talk groups. Wide area talk groups would allow users in widely separated parts of the state to communicate with each other.
   g. Talk groups and individual paging on a state-wide basis.
   h. Many users certainly need to monitor talk groups that they would not normally be allowed to transmit on
   i. Equipment must be capable of using both Data and Voice encryption technologies
   j. Some talk groups will need to be usable, continuously, across large geographic areas.

2. Basic Functionalities:
   a. voice dispatch
   b. car-to-car voice
   c. car-to-car data
   d. data dissemination from dispatch centers
   e. paging (digital and voice)
   f. wireless portable/personal computer and fax modem support
   g. local system interconnect for early warning systems.
   h. emergency call box handling

3. System Interconnectivity for coordination and mutual aid:

a. Linking trunked digital to conventional analog networks
b. Telephone interconnect capability:
c. NLEEC availability:
d. Compatibility with existing specialized equipment:

4. System Coverage:
   a. Propagation/penetration requirements

      Current systems design proposals provide 90% coverage 90% of the time statewide. For some areas this level of coverage represents a significant improvement, for others, it may not be adequate. A higher percentage of coverage overall may be cost prohibitive (e.g., raising statewide ceilings to 95% coverage for 95% of the time). In metropolitan areas and particularly in institutional facilities such as college campuses, hospitals and prisons, coverage's of necessity may need to approach 99% or better.

5. System Reliability
   a. Fault tolerance

      System needs to be fault-tolerant. Individual hardware pieces will fail; these failures should not impact the operations of the system assuming they are repaired in a timely manner. The system architecture should also provide considerable fault tolerance. Improved performance should be expected due to automated features of "smart radio systems" which will deploy adjacent repeaters in other sites to maintain talk groups at optimal levels.

   b. System maintenance must not affect operations.

      System needs to provide reliable, clean, interference-free communications. There should be no interruptions or degradation of service when routine maintenance is being performed. Redundancy or "fault-tolerance" should allow for scheduled maintenance as well as system failure, and switch automatically to alternative facilities.

6. System Capacity

   It should be understood that trunked systems by their nature provide a much higher capacity for communications than conventional systems. In light of this fact, what are the projections for users' needs that will outstrip this additional capacity?

   a. The possibility of more directed and 'private' conversations, may create a use that has primarily been satisfied by telephones today.
   b. The possibility of wide area communications will add additional burden on the system.
   c. By far, the largest impact on the new system will be the need for data transmissions between dispatch centers and field units (such as wireless personal computer terminal modems for data exchange such as digital data queries, faxes and interactive crime reporting.)

7. Catastrophic or Major Event Impact on Communications Systems

   a. Communications Systems must be designed to resist impact of catastrophic events (e.g. natural hazards such as earthquakes, floods, wildfires, tornadoes, hazardous materials incidents, etc.)

   Communications systems have been shown to be vulnerable to natural hazards such as floods, wildfire, tornadoes, earthquakes, etc., and tend to fail when they are most urgently needed. Experiences in the recent mid-west floods and California earthquakes and wildfires have painfully reminded public safety officials of the vulnerability of communications systems which are not designed with several layers of "redundancy" or "fault-tolerance." A "devil's advocate" review of system reliability should be conducted by experienced emergency management and engineering personnel in a "table-top" exercise. Such an exercise would serve to answer most "what if..." questions that might not otherwise be considered in normal system planning. By providing several layers of redundancy in the system design, and adding "fail-safe" features, the reliability of a system can be greatly improved. Localized system failures due to site or equipment damage or loss can be automatically compensated for by automated switching to adjacent sites. In extreme cases with wide area failures, a mobile or portable emergency backup system could be brought in to serve the area until service of the permanent system can be restored.

   b. Management of Mass Events

   Mass events affecting multiple jurisdictions or service areas include regularly scheduled athletic competitions or celebrity entertainment where attendance may approach 100,000 in metropolitan areas. Unusual events such as the hosting of international celebrities or heads of state may result in substantially higher attendance and resultant impact. A recent example was the "World Youth Day" event of August, 1993, that was attended by nearly 400,000 youth and visitors from throughout the world, as well as the Pope, the President, and many international dignitaries and heads of state. Despite unanticipated demand for emergency medical services which exceeded maximum projections by tenfold, the communications system was not challenged. This event was handled by two permanent and one special trunked radio system. Statistics on system use and impact during this event from the various agencies indicated a transmission volume over 100,000 messages on peak days which utilized less than half of the capacity of the system at peak intervals. Conventional non-trunked systems would have been overwhelmed by such loading due to lack of automated channel management afforded by trunking. System design should include capacity and reliability to network with all appropriate agencies to effectively coordinate such events.

   c. Options for System Development and Enhancement

Sharing of existing sites becomes increasingly important to enhance redundancy, reliability, and effective propagation/penetration. It is more cost-effective to install trunking equipment on developed sites shared between federal, state, and local government agencies as well as the private sector. Grant programs and coordination/technical advice should be pursued from Federal agencies (e.g. the Federal Emergency Management Agency or FEMA; and the Department of Commerce/National Telecommunications and Information Administration). Future expansion through satellite links should also be anticipated when/if technology becomes cost-effective and/or feasible.

Dispatch and Communication Centers

1. Administration of Systems

a. Agencies definitely need control of their talk groups. It should be understood that while some agencies are geographically bound, others are not. Talk groups need to be rapidly re-configurable. In emergency operations, new field units may need to be added to talk groups that were not planned for in the engineering of pre-plans.
b. Define and limit the number of talk groups usable by each agency. This prevents a particular agency from saturating the system and preventing access by other users.
c. Administrative help from the state will be needed for smaller agencies that ordinarily do not have a need for personnel proficient in administering the system.

2. Operational Characteristics

a. Provide supervisory capabilities to prevent misuse of private trunks
b. Provide system utilization data to monitor the system loading in real-time.
c. Provide system and field unit utilization history.
d. Provide lockout for malfunctioning or illegal field equipment.
e. Provide user-friendly diagnostics, designed for dispatch personnel, not just system technicians.
f. Dispatchers must be able to configure simultaneous broadcast over multiple talk groups within the agency and the talk groups of other agencies by agreement. These talk groups may or may not be geographically local. The voice source may be within the comm-center or may be from a field unit, or some other comm-center.
g. The logical control point for activation of emergency public warning systems is in dispatch centers. Warnings initiated by one center must be easily disseminated to geographic areas affected by the hazard, as

well as to other centers which may have adjacent warning and response authority.

3. Documentation and Recording of Transactions

a. All digital/analog communications (voice or data; encrypted or non-encrypted) should capable of being recorded as required for legal/liability and statistical analysis/management purposes. (This includes unit-to-unit field transmissions in various talk-groups which would not normally be monitored by a dispatcher in a Communications center.

4. Encryption

a. A major failure of present analog systems is the lack of protected/secure communications for sensitive information. It is anticipated that with the inclusion of encryption as a standard feature for digital trunked radio, user groups will be increasingly disposed to utilize encryption when secure operations are necessary. Agencies which have utilized encryption extensively have received considerable pressure from news media to discontinue encrypted messaging and/or to provide the media with some kind of "licensed" access via monitors capable of receiving encrypted messages.
b. Implementation of encrypted voice/data transmissions in various talk groups should be easily accomplished through automated and/or remotely initiated commands to appropriate units.
c. Documentation/recording of encrypted transmissions for voice or data transmissions may present a challenge to system administration unless provisions are made for automated decoding/recording of such transmissions in the appropriate administrative service authority communications centers.

Field Operations (Mobile)

1. Data Support Capabilities:

Mobile units must have high speed data interfaces providing connectivity to multiple digital devices that could be installed in mobile environments. Examples of such devices are:

a. Fax machines
b. Mobile/portable wireless modem interface data terminals
c. Printers
d. Automatic vehicle location systems
e. Automatic Finger-print Identification systems
f. Vehicle Management Systems
g. Digital interactive (two-way) video/audio support

2. Voice Support Capabilities
    a. Compatibility with conventional units
    b. Digital storage of received audio for later playback
    c. Alternate audio interface for relaying of previously recorded audio to a base
    d. Car-to-car simplex communications
    e. Car-to-car communications with use of repeater or relay. This implies communications between any participating units in the state
    f. Mobile unit as mobile repeater/relay for portable units.
    g. Receive & display Auto-Identity information for voice communications

Field Operations (Hand-Held)

1. Data Support Capabilities:
    a. Alpha-numeric paging
    b. Interfaces for ADA equipment
    c. “Palm-top” (wireless modem) hybridized voice/data terminal

2. Voice Support Capabilities:
    a. Compatibility with conventional units
    b. Digital storage of received audio for later playback
    d. Simplex car-to-car communications without use of repeater or relay
    e. car-to-car communications with use of repeater or relay.
    f. interact with mobile as relay/repeater transmissions from a hand-held unit and also in the secondary use of relaying transmissions from a base to a hand-held unit which is local to the mobile unit, but cannot receive the base unit)
    g. Receive & display Auto-Identity information for voice communications
    h. “Emergency/Officer Needs Help/Officer Hostage” alarm signal button/key activation feature.
3. Environmental Capabilities:
    a. Portable and mobile equipment shall (when necessary) meet requirements for intrinsically safe operation for hazardous materials/explosive atmospheres and wet environments.

Field Operations (Base**)**

This refers primarily to remote base stations such as PD annexes, Fire Stations, Park Ranger offices, etc. The functionality of mobile units applies here also. In addition:

    a. Integration to Intelligent Facilities Systems

i) Station Door Operation
ii) Vehicle Bay and Outdoor light operation

Talk Group Prioritization

Overview:

Talk Group Prioritization (talk groups) is defined in terms of the priority for use of the system by various user groups. The following system of Talk Group Prioritization is recommended:

A. Levels of Priority Defined

I = First (highest) priority:
Life Safety top priority access for first responder public safety officers (e.g.,. law enforcement, fire, medical, et al) to Central Communications Centers for control and coordination of life safety priority emergent requests/responses (e.g., "officer needs help, officer down, shots fired, etc.).

II = Second Priority:
Control and coordination of large scale or catastrophic disaster events with massive life-safety and property impact (e.g., a large natural disaster affecting multi-jurisdictional and/or governmental boundaries such as Federal, state, and local Government, and also the private sector. Priority for such use is justified due to the significant and broad-based risk to life and property. Responsibilities include public warning and evacuation over large geographic areas. (examples: large earthquake, large wildfires, widespread flash flooding, hostile attack, et al.) Function includes warning and evacuation, coordination and control of emergency management operations through Emergency Operations Centers (EOC), and Incident Command Systems (ICS). Immediate response as well as long-term response and recovery control operations and coordination would be a function of the system (priority use would revert to lower levels during recovery phases.)

III = Third Priority:
Control and coordination of localized disaster events with significant life-safety and property threats (e.g. a moderate natural disaster such as a flash flood, wildfire, earthquake, or multi-jurisdictional response to major crimes such as a terrorist incident, sniper or automatic weapons assault, et al.)

IV = Fourth Priority:
Control and coordination of routine public safety events requiring non-urgent response on a local basis.

V = Fifth Priority:

Control and coordination of governmental operations involving non-urgent routine responses and data management, interconnect functions, etc.

VI = Sixth Priority:
Control and coordination of non-emergent communications for non-governmental and auxiliary user groups; private sector interface, et al.

Talk Groups Defined

Overview:

Talk Groups are defined by user group needs. A typical local talk group might include a geographic area defined by the city limits (or slightly beyond) of a city or town. A regional talk group might include multiple jurisdictions within a county (e.g., several cities, towns, county government, and interactive agencies on a federal, state, and local level (e.g., State Patrol, Division of Wildlife, FBI, highway maintenance, parks, et al). The geographic "service area" Public Safety Communications Center (which customarily provides system access to the public for enhanced 9-1-1 service, and controls/coordinates the dispatching of public safety responders in that service area) would define the local, regional and statewide/interstate talk groups needed to provide comprehensive communications services to that area.

A statewide/interstate talk group might enable an authorized user to communicate with units of his own agency throughout the state (e.g., State Patrol, Division of Wildlife, State Parks, et al). State, regional, and local user group agencies would also be able to interconnect with agencies in adjoining states which may border their jurisdictions Additionally, local jurisdictions may be provided access to statewide talk groups in specific applications; For example, a sheriff's deputy transporting a prisoner from northwest Colorado to Canon City would be able to continuously access his/her home Communications Center in Craig, as well as any number of Communications Centers which serve the areas the deputy is passing through on the way to Canon City. If that officer requires assistance at any time during the trip, (s)he is never out of reach of either his/her home jurisdiction, or the jurisdictions through which (s)he is passing. The officer may be able to directly access the Corrections facility which is the ultimate destination.

Talk Group Classification

Overview:

Talk Groups are classified, as noted above according to use on local, regional, statewide/interstate categories. Within these categories are subsets of user groups which have been defined according to function. Within the general categories listed below, would be layers of different jurisdictions (e.g., federal, state, local, and in some cases private sector.) The following table defines the format for establishing talk groups according to those categories. Some tailoring

and modification of structure will be necessary for each "service area" or jurisdiction to meet specific local, regional, or statewide needs.

FUNCTIONS	AGENCY	COUNTY	REGION	STATE	INTERSTATE
SPECIAL EVENT/SITUATION	1	1	1	1	1
LAW	1	1	1	1	1
FIRE	1	1	1	1	1
EMS	1	1	1	1	1
SEARCH & RESCUE	1	1	1	1	1
MUTUAL AID & TACTICAL	1	1	1	1	1
WORK/UTILITY/MAINTENANCE	1	1	1	1	1
ADMINISTRATION/MANAGEMENT	1	1	1	1	1

Mutual Aid Networks/Channels

Existing mutual aid channels/networks are dispersed among different bands (VHF, UHF, 800 MHz) according to service category of law, fire, EMS search and rescue, and federal/state/local jurisdiction. It is necessary to consider these existing channels, and to determine appropriate digital trunked radio complementary channels and networks which will interface with them, and/or eventually replace them.

Existing mutual aid networks/channels

LAW

N.L.E.E.C (1 VHF) nationwide analog channel (155.475 MHz)

C.L.E.E.R. (1 UHF) eastern front-range coordination for metro areas (460.425 MHz)

FIRE

F.E.R.N. (3 VHF) nationwide analog channel 154.280 MHz, 154.265 MHz, 154.296 MHz)
AIRNET (1 VHF) airborne fire suppression net (U.S.F.S.)
WORKNET (1 VHF) regional wildland fire suppression (U.S.F.S.)

E.M.S.

12 E.M.S. (UHF) CHANNELS (nationwide authorization) for ambulance to hospital, hospital to hospital, etc.

2 H.E.A.R. (hospital emergency administrative radio) VHF channels 155.280, 155.340 MHz, plus other special emergency channels (VHF, UHF) in various areas.

MOUNTAIN SEARCH & RESCUE/SKI PATROL

N.S.A.R. (1 VHF) nationwide use for mountain search and rescue and volunteer and National Ski Patrol coordination (155.160 MHz)

800 MHz MUTUAL AID CHANNELS

ICall, ITAC-1, ITAC-2, ITAC-3, ITAC-4

Statewide alerting/information network

Overview:

Users have expressed a need for an efficient statewide alerting network which provides automated informational updates via voice and/or alphanumeric paging, wireless modem "palm-top" units, etc. A significant problem which occurs in virtually all jurisdictions is non-communication between different agencies which may work in a particular geographic service area, but be dispatched by a different communications center (e.g., the U.S. Forest Service may have a ranger working in a law enforcement situation requiring 'cover' for an uncooperative suspect.). His service area communications center may be remote from the primary public safety communications center. Therefore, unless (s)he has direct access to the primary public safety communications center channels in the service area where (s)he is working, the officer's own dispatcher is the only link to the other center for initiating mutual aid assistance. There might very well be a wildlife officer within five minutes travel time of the forest ranger, who is not alerted to the mutual aid request. The communications center relies on normal protocol to send a Sheriff's deputy who may be much further away. Similarly, a State Patrol unit might be closer, but because of protocols, the communications center dispatcher may not opt to ask for mutual aid from CSP communications center, even if their car just happens to be much closer. However, if either the State Patrol or Wildlife Officer has the public safety communications service area operations channel programmed into their units, and IF they are scanning and happen to hear the call, they may elect to respond on their own. Often, however, this does not happen. Therefore, what is needed is a comprehensive alerting system which can quickly and comprehensively deliver such information to a wide variety of public safety officers in all jurisdictions ranging from federal, state, and local who may have occasion to work in the particular service area.

Concept of System

This network would provide "B.O.L.O." (be on the lookout for...) information on wanted persons, suspect/vehicle information, major emergencies/events in various regions, etc. The system would be an extension and/or expansion of the current CCIC/NCIC B.O.L.O. or regionalized network messaging systems (e.g. "metro, crime, I-25, I-70," etc.). Too often, information which could be useful to various agencies/jurisdictions falls "through the cracks" in terms of dissemination,

either because it is not transmitted by a dispatcher when it is received from a CCIC terminal, or because if it is transmitted, it is only done on certain channels which users in a given area do not monitor. If a dispatcher can simply draw a "polygon" or box on a computer assisted dispatching (CAD) screen around the geographic area where the mutual aid is needed, then any car/unit from any jurisdiction which is equipped with this alerting network will be simultaneously notified of the request, and can notify the communications center of their location/availability to respond. (It may be that if Automatic Vehicle Locator (AVL) systems are implemented, the availability of all public safety units in a given geographic service area will be displayed for the dispatcher much as an aircraft transponder "squawks" an identification code and location point to the Communications center AVL mapping display. Therefore the location of all available public safety units who could respond is instantly displayed and recommended to the dispatcher who may then pick the computer's recommendation, or override and send other units. The advantage of this type of network is that information can be sent out in large volumes, stored in a message buffer for the receiving unit, and addressed by region so that all users having need to access the information can be rapidly alerted. Priority alerts such as pursuits, armed robberies, hazardous materials incidents, "officer needs help" mutual aid requests, could be programmed and transmitted by "polygon" or regionalized computer mapping to all appropriate layers/jurisdictions in areas which are potentially affected by the alert. An alert tone/light can be activated for priority messages on the receiving units when officers need to be instantly advised of urgent events. "Fax-type" printouts of the information can be generated on palm-top wireless modem radios when needed, including photographs, maps, diagrams, fingerprints, etc. A significant advantage of this network is that it does not "clog" voice channels with vast amounts of information which preclude use of the channel for emergent radio traffic, and yet public safety officers can easily be kept informed of all pertinent events in their jurisdictions. The network can easily be expanded to other categories beyond law enforcement, including fire, EMS, search and rescue, utilities/maintenance, administration, etc. Access to a variety of information such as CSP road condition reports, national weather service weather warnings, meteorological data such as storm cells, wind, fire danger, avalanche danger, etc., could easily be linked into the system.

Emergency Outdoor Telephone System

Overview:

Emergency System entry access by the public to central emergency communications centers for emergency assistance is often difficult in remote rural areas and urban highways due to lack of available and easily identified emergency telephones. This deficiency is often the result of a lack of communications facilities (e.g. phone lines/radio system, etc.) to support emergency access. Cellular Service is often not available in isolated areas due to

low subscription potential, and does not presently lend itself to ANI/ALI recognition. A statewide network of emergency outdoor telephones is essential to obtaining emergency help rapidly and reliably. In many areas, it is not practical to install wireline or cellular-based emergency call boxes. Since all emergency call box use must be directed to a dispatch center, utilization of a digital trunked system is an appropriate and logical application.

A. Basic Functionality:

1. Voice capability
2. Caller ID (ANI/ALI)
3. Call Back, by dispatch or other field units
4. Standardized, vandal-resistant, well-marked, illuminated units (flashing blue strobe) and overhead safety lighting.
5. Solar-powered battery-operated units in remote areas.
6. Public education campaign to familiarize public with availability and use of system
7. Future consideration of digital interactive video from site of callbox

Emergency Medical Services Support

Overview:

Emergency Medical Services (EMS) is a major component of the system requiring networking as well as regional control and coordination of services. Many rural areas of the state have inadequate communications for EMS systems allowing for comprehensive patient reporting, consultation with physician advisors, connection with major trauma centers (level I, II) and aeromedical evacuation and coordination. A trunked radio system design should evaluate the deficiencies and needs of EMS, and provide for effective control and coordination. Some of the concepts suggested for EMS include live color interactive video/audio conferencing between hospitals and field paramedics, vital signs telemetry (e.c.g., e.e.g., blood-gas analysis/pulse oximeter, wireless modem palm-top communications, differential diagnostics linking with trauma center computers, etc.) It is intended that the digital trunked radio system will serve as the communications backbone for the new statewide trauma system being developed as a result of recently enacted legislation.

6.3 DIGITAL TRUNKED SYSTEM

The system will utilize two technologies not currently utilized by the majority of the systems operated by the State and local agencies. The first technology is trunking and the second is digital transmission. Each of these technologies offer substantial improvement in capabilities over today's systems. The combination of these two technologies will create a new wireless system, with many new features that will allow the user to have access to various types of voice, data

and graphic applications. The system will also provide the capabilities for many new services including; Intelligent Vehicle Highway Systems, Emergency Medical Services and alarm and control systems.

6.3.1 FREQUENCY BAND

One of the biggest issues in the final design is what frequency band will be utilized. The majority of the existing systems used by State agencies operated in the 150-160 MHz (VHF) band. Current FCC rules do not allow trunked systems to operate in this band. All trunked systems must be located in the 800 MHz band under current FCC rules.

The assignment of frequencies for public safety in governed by the Region 7 (Colorado) Public Safety Plan. The Plan was submitted and approved by the FCC and provides specific eligibility requirements, frequency allocations and system design considerations. The State has been assigned numerous channels for statewide use. There are also numerous channels that are unassigned and may be used for future growth as required.

The FCC has initiated a complete re-write of the rules for all frequencies below 800 MHz and above 50 MHz. This re-write is commonly referred to as “Part 88”. The proposed changes in Part 88 include allowing trunking in the VHF band, splitting channels to create more channels and limitations on transmitter power. The most notable affect of Part 88 will be the complete replacement of all radio equipment currently in use by state and local government agencies. There will be an extended time frame to allow for amortization of the existing equipment. The exact time frame and final rules are expected to be released in the spring of 1995. Frequencies in the 800 MHz band are not affected by Part 88.

Initial estimates indicate the cost of the system will be 20 - 30 % higher to use 800 MHz compared to VHF. Part 88 will have a significant effect on the VHF band for many years to come and this band will be in a state of dynamic change. The lack of additional channels and this uncertainty of the VHF band will most likely make 800 MHz the best choice for the new system. There are an adequate number of channels for the system with more channels available for future growth. The only changes in the 800 MHz band will be splitting the existing channels to narrow band channels for new digital systems. This change will provide more channels and is in line with the digital standards for new systems.

All preliminary system planning will be done to accommodate the new system in either band. Final engineering will begin in 1995 and a final choice of the band will be made at that time. The most likely choice at this time is 800 MHz.

6.3.2 SYSTEM COVERAGE

The other significant factor in selecting the band is the radio signal coverage area from each transmitter. The terrain in the State plays a critical role in the range of the transmitters. The general rule is the higher the frequency the shorter the range. The VHF band provides greater range than 800 MHz under normal

circumstances. It is possible to compensate for the loss of range at 800 MHz with high gain antenna systems that are not possible in the VHF range.

Initial computer generated coverage maps in the 800 MHz band show a 25 - 30 % reduction in coverage compared to the VHF band. This loss will require additional sites to fill the holes created at 800 MHz. The Division of Telecommunications will be conducting field comparison test in late 1994 and early 1995 to determine the actual differences and to obtain data to verify the computer predictions. If substantial differences are realized, the computer model will be modified and new predictions done.

One simple and cost effective method to fill the coverage holes will be sharing of sites owned by local, federal or commercial agencies. This would eliminate the cost to construct additional sites. The only cost would be to interconnect the these sites to the State network. Sharing of sites would also make it easier for non State agencies to share the system.

The coverage design criteria will be to provide coverage in 90% of the State, 90 % of the time for a portable radio operating outdoors for the wide area portion of the system. Local or facility based systems will be designed for the specific requirements of each facility. Non State agencies that participate in the system, whose needs are not met by the initial coverage criteria will be addressed on a case by case basis. Costs associated with improved coverage will be the responsibility of that agency.

6.4 STANDARDS

While APCO Project 16 defined a specific set of operational requirements for trunking, it did not specify a standard methodology for achieving them. Each manufacturer could meet the requirements using their own design, control methodology and software. As trunking systems became more prevalent for public safety, a couple of significant problems were encountered.

6.4.1 Proprietary systems

Proprietary systems have led to an inability for inter-operability between agencies using systems of different manufacturers. An excellent example of this is with the cities of Denver and Aurora. Denver is using an Ericsson/GE 800 MHz analog trunked system. Aurora is using a Motorola system. While both systems fully meet APCO project 16 requirements, and also meet the needs of each city by providing quality and reliable communications, units from Denver cannot access the Aurora system, or vice versa. This lack of interoperability between systems has been identified by the users group as a key issue that must be addressed in a new system.

The other issue created by proprietary systems is the inability for competitive purchasing to expand or upgrade existing systems. Government agencies rely heavily on the competitive bidding process to get the most for the taxpayer dollar.

Since additional equipment for existing systems must be purchased from the original vendor, the competitive bidding process is lost. This leaves vendors with little incentive to increase discounts for future purchases. This also eliminates many other suppliers of radio equipment from bidding and selling equipment.

6.4.2 APCO PROJECT 25

APCO Project 25 is a joint government/industry standard-setting effort to develop technical standards for the next generation of public safety radios, both voice and data. This standard employs state-of-the-art digital technologies rather than the older analog technology of today's systems. The more apparent user benefits are interoperability between agencies and between different levels of government, and competitive procurement. Not as apparent, but of equal importance, are issues of graceful system migration (forward and backward) and efficient use of the radio spectrum., this last issue is critical as agencies continue to grow and add new services.

First, a review of some basic terms: Radio channels are measured in band-widths of Hertz, or cycles per second. Standard voice channels are measured in thousands of Hertz or kilohertz (KHz); voice channels are typically 25 KHz wide. Commercial television channels, by comparison, are 6 million Hertz or 6 megahertz (MHz) wide, enough to hold 240 standard 25 KHz voice channels. Radio bands normally used for public safety voice communications fall within the range of 30 to 870 MHz. When Project 25 technology is implemented, it will initially provide twice as many channels in the UHF (450-470 MHz) and 800 MHz bands by splitting channels in half from their current 25 KHz bandwidth to 12.5 KHz. In the popular VHF High band (150-174 MHz), a reduction from the current 15 KHz channels to 12.5 KHz channels will provide at least a 6-for-5 gain, in addition to allowing use of adjacent channels in the same geographic area (which is currently impossible). Project 25's ultimate target of a 6.25 KHz channel will again double all these capacities, providing a 4:1 gain over today's 25 KHz channels in the UHF and 800 MHz. bands.

Founded in 1935 as the Association of Police Communications Officers, APCO has a long history of involvement in activities like Project 25. Among its early efforts was the development of the Standard 10-Code now used by agencies throughout the world. In the technical arena, it is perhaps best known for its Project 16 "800 MHz Public Safety Trunking Recommendation," developed in the late 1970s and early '80s. APCO is designated by the Federal Communications Commission (FCC) as the frequency coordinator for the Police Radio Service. APCO's recent name change—to the Association of Public-Safety Communications Officials, International—more clearly represents today's association.

BACKGROUND

One of APCO's major activities since its inception in 1989, Project 25 is the first-ever standard-setting effort of any kind involving public safety agencies at the

local, state and federal levels. Key to some of the attendant turmoil is the fact that Project 25 is also the first-ever standard-setting effort within the telecommunications industry that is user-driven and user-controlled. In the past, manufacturers have designed and built products based on technology that they had developed in an attempt to meet public safety needs. Individual companies produced products (often proprietary) that they then promoted to gain market share.

Project 25, on the other hand, is reviewing various available technologies and selecting those that a representative and technically knowledgeable group of users believe are the most appropriate and cost effective for public safety. In one case, the quest for graceful migration actually forced the development of a new piece of needed technology.

Project 25 is governed by a nine-member steering committee with equal representation from each level of government. Three APCO members represent the local level; three National Association of State Telecommunications Directors (NASTD) members represent state government; and the federal government is represented by one member each from the Department of Defense, the National Communications System and the National Telecommunications and Information Administration. APCO and NASTD each provide an additional member to serve as co-chairs of the committee.

Project 25 has a Memorandum of Understanding (MOU) with the Telecommunications Industry Association (TIA), the major trade association for land mobile radio, and the telecommunications standards-setting branch of the American National Standards Institute (ANSI). Through this MOU, an industry advisory group, TIA-25, has a key role in Project 25.

HISTORY

Project 16 was a functional/performance recommendation that defined user features without telling manufacturers how to build them into the system; it was not a technical standard. Though never formally adopted by a recognized standard-setting organization, Project 16 became a de facto standard that is referenced in virtually all analog public safety trunked system procurements today. However, because it was functional rather that technical, it led to incompatibilities such that systems produced by the major manufacturers (EF Johnson, Ericsson-GE and Motorola) are not interoperable in a trunked mode. Once a vendor is selected, the user is generally locked into that vendor's products for the life of the system. Similar problems have arisen with products for voice encryption where, again, equipment is unique to each manufacturer and not interoperable in encrypted mode.

In the mid-1980s, there was a call to establish trunking standards for 800 MHz analog trunked systems. This effort, led by a group call OARPS (Open Architecture Radio for Public Safety), included a number of the leading proponents and opponents of Project 25. After close examination by APCO and by the FCC, agreement was reached that, although the large embedded

equipment base made it impossible to establish such a standard retroactively, a standard for the developing digital technology would not only be desirable, but mandatory if interoperability were required. In 1988, the FCC issued Docket 88441: "Advanced Technology for the Public Safety Radio Services," ushering in Project 25 in October 1989.

During this same period, user-based agencies of the federal government were evaluating changes to enhance spectrum use, take advantage of digital technology, examine the potentials of trunking federal radio channels, standardize voice and data encryption products and promote competitive procurement. It was only natural for them to join the Project 25 effort.

From its inception, Project 25 has had international perspective. Both government and industry representatives from Australia, Canada and the United Kingdom have been active participants, and interest has been expressed by China, Denmark, France, Germany, the Netherlands, New Zealand, Spain and Taiwan. The product of an estimated 500,000 man-hours (almost 250 man-years) of labor by users and industry over the past five years, as well as countless dollars spent on research, travel and management, Project 25 is an extraordinary endeavor.

THE BENEFITS OF PUBLIC SAFETY RADIO STANDARDS

From the user's perspective, standards ensure interoperability, provide backward compatibility to today's systems and forward migration to tomorrow's systems, help control system costs, increase spectrum efficiency, simplify communication system decision processes, set effective levels of system performance and provide an opportunity for multi-vendor procurement. From the manufacturer's perspective, standards define and accelerate market adoption of new technology and limit the number of technologies that manufacturers must offer to markets.

Project 25's goal is to develop a suite of standards focused on the six system interfaces: data interface, common air interface (CAI), intersystem interface, host data interface, interconnect interface and network management interface. This suite encompasses in detail the operating parameters of major system components such as the vocoder (voice coder, which converts analog voice from the microphone into a digital signal at the sender's end for transmission and then converts it back to analog at the receiver's end for projection from the speaker), the modulation system (which encodes the digital signal onto the airwaves), the method of accessing the radio channel, trunking protocols and multi-level secure voice encryption with over-the-air rekeying (OTAR).

Project 25 initiated tests of several vocoders by the U.S. Air Force; results were analyzed by an independent laboratory in Canada. The Improved Multi-Band Excitation (IMBE) vocoder selected for Project 25 is used by the International Maritime Satellite group (INMARSAT) for marine satellite communications and is a finalist for TETRA (Trans-European Trunked Radio Standard) in Europe. With unanimous approval by TIA-25 and the Steering Committee in early 1992, the IMBE vocoder will be published by TIA as an "interim standard."

Of the six interfaces, the CAI has been the most controversial within the TIA-25. By majority vote, the CAI was forwarded to the steering committee as the recommended standard. However, the manufacturers have yet to reach the required consensus within TIA to publish the CAI as an interim standard. In October 1993, the steering committee adopted the CAI as a "Project 25 Recommended Standard" for public safety digital radio systems, giving it the same weight as the "Project 16 Recommended Standard" for analog systems. Within the CAI, the most discussed issues are channel access method, data rate and spectrum efficiency.

6.5 MANAGEMENT AND CONTROL

A key function in any network and especially one as large and complex and a state wide digital trunked system in the management and control. The APCO 25 standards have included this as an inclusive feature. The use of microprocessor and software technology in trunked radio systems make this complex function possible.

There are several level of management and control that will be included in the State system. These include overall system management, fault alarms, talkgroup assignments, agency subscriber units, resources management and dynamic regrouping. The Division of Telecommunications will function as the overall system manager with the State Patrol communications centers providing 24 hr operational management and control. Non State agencies will have the option of the State functioning as their manager or providing their own management and control of their system resources, talk groups, communications center equipment and subscriber units. Any additional equipment necessary for non state agencies to provide their own management will be paid by the agency. This capability can be provided using password level access in the network management system. The system is also capable of providing printed history reports for overall system usage, agency usage, individual unit usage, type and duration of messages including emergencies on an annual, monthly, daily or hourly basis. The management and control system provides a very effective method for assuring maximum up time and usage of the system.

The management and control system will also provide system security to prevent unauthorized users from access to the system. Agencies choosing to provide their own management and control will be restricted to their radios and talkgroups through multi level password control. This will also prevent access to other groups using the system.

6.5.1 SYSTEM MANAGEMENT ADVISORY COMMITTEE

At the recommendation of the users group the State intends to establish a System Management Advisory Committee. The purpose of the System Management Advisory Committee will be to provide direct input on the management and control of the system especially for non state agencies. The

Committee will also be instrumental in resolving special situations or non standard uses and participation of the system.

6.6 COMMUNICATIONS CENTERS

Those agencies that currently provide dispatch services and choose to use the State system will still have the ability to provide dispatch services. Utilizing the State system will significantly improve the capabilities and range of the communications centers. It will not be necessary to use State operated centers. If an agency is currently using a State operated center that will be closing as part of the State Patrol consolidation plan, they may choose to continue being serviced by the regional center, join another existing center in their area or begin providing their own dispatch services. All cost associated with non State agency communications centers will be the responsibility of those agencies participating in the center.

6.7 SHARED USE OF DIGITAL TRUNKED RADIO SYSTEM

The users group has identified 5 membership levels of non state agency participation in the system. The 5 levels will give agencies a choice to select the level that meets their operational needs and financial ability.

The Colorado Trunked Radio System will provide services to a large number of state and local agencies in Colorado. The radio system will directly replace existing systems and provide services to the Colorado State Patrol, Department of Transportation, Department of Natural Resources, Department of Revenue, Office of Emergency Management, Department of Corrections and Higher Education. (Existing system maps are located in appendix 12.7)

In addition, the system will be available to several types of membership by other organizations, including state, county, municipal government agencies, Federal agencies, and certain service organizations. The rules for eligibility are defined in the Region 7 Public Safety Plan, Once an organization qualifies under the eligibility rules, it can participate in the Colorado Trunked Radio System via any of the following types of membership.

6.7.1 Client member

State of Colorado furnishes services (possibly even equipment) to the user. This will typically be a smaller agency, often in a rural area. The State furnishes a client the use of the existing State network. Depending on the entity, the State may be reimbursed for any capital and service costs, though such clients would generally “piggy-back” on existing state services, without requiring the state to construct additional facilities on their behalf. Client members would be expected to pay for their own radios and, possibly, a monthly or yearly service fee.

6.7.2 Integrated Member.

These members would generally be small-to-medium size users who have chosen to abandon (or have refrained from building) their own radio systems, but have asked the State of Colorado to specifically include facilities to meet their needs in an augmented Colorado State network. The Integrated member would generally pay the State to build and operate a system for the user, and would probably pay a fee for services. Unlike the Client User, the Integrated member would require a modification or addition to be made to the State network.

An Integrated Membership would be advantageous for a typical smaller system, where the incremental cost of adding to the Colorado System would be considerably less expensive than the construction of a whole new separate small system. Such a membership might not be advantageous if providing the needed facilities required substantial modifications or additions to the Colorado System, costing more than separate facilities.

6.7.3 Cooperating Member

In this case, the member (e.g. a county) builds its own network primarily to meet its own needs. However, the system is designed to meet exact compatibility and operational specifications, so that the user's system can be easily integrated as a major node of the statewide network. State Patrol and Division of wildlife vehicles, for example, traversing the county service areas would obtain seamless service from the county system.

The system remains county property and is under the control of county personnel. However, it is fully integrated into the state-wide net for the purpose of shared operation for foreign (i.e., outside of the county) users. This includes complete operation of encryption keys, various use authorizations, etc. Under exceptional circumstances, the county might be required to provide priority service to particular foreign operations.

The Colorado State network would generally not exist as an independent network in the territory served by a Cooperating System; it would exist only as a virtual network using the physical facilities of the Cooperating System. In some areas, state microwave links might traverse the geography of a Cooperating System. In some cases, the Colorado system might need to augment the capacity or the features of a Cooperating System, in order to meet anticipated State system needs. In this situation, the State would reimburse the Cooperating system for the additional incremental costs, as well as a prorated share of maintenance and operations costs. In addition, the State of Colorado would furnish and maintain the hardware, software, databases, and personnel required to integrate Cooperating Systems into the State network.

In exchange for participation as a Cooperating member, the Cooperating member would gain access to the State of Colorado system on a state-wide basis. In general, the system would operate seamlessly, allowing any user to follow identical procedures no matter whether he was being served by a State System or a Cooperating member. In various areas throughout the state, some

special features (like broadband digital data links) might not be available, depending on exactly which features had been implemented locally.

6.7.4 Associated Member

The Associated Member, like the Cooperating Member, has built its own system, following Colorado State standards to maintain system to system compatibility. An Associated Member would be granted the use of the Colorado System on an occasional and non-binding basis. Foreign use of the Associated System would be on an occasional and non-binding basis. Priority use of the system by a foreign user would only occur on a voluntary basis. There would tend to be a lower degree of integration between an Associated Member and the Colorado State system, and foreign users might not enjoy the use of a full range of services.

Because an Associated member would have no legal obligation to permit long-term sharing by other State system users, the State system would generally need to provide its own parallel coverage of Associated system territory. The State would generally not provide additional capacity or pay any construction costs of Associated member systems. The total costs of the independent systems would be expected to be larger than the total cost associated with an Cooperating member or integrated member systems.

Associated Membership might be useful where high-priority agency missions (or turf issues) cause administrative difficulties in temporarily subordinating the agency mission to foreign control of assets, or where equipment/frequency band incompatibility prevent a full implementation of Cooperating Membership. Associated membership might be used on a voluntary basis to mutually share trunked loading of a limited number of channels and to obtain State coverage of areas near Associated member transmitter sites and vice versa, or to gain additional capacity during planned special events.

Some agencies might initially choose Associated Membership, with Cooperating Membership being a later option.

6.7.5 Commercial Member

A limited amount of use by commercial organizations will be permitted under certain circumstances. For example, commercial groups who are working closely with Government agencies using the Colorado State system might be given access to the appropriate talk groups (e.g., commercial ambulance or towing companies). Under these arrangements, however, commercial talk group access would not include normal government working channels, but would include special talk groups used to coordinate operations between government and commercial organizations on a case-by-case basis. In addition, a rancher/forester/guide might be given permission to use the system in remote areas of the state where other communications is not available, for purposes of safety/emergency communications. These uses should be on a very limited basis, including full cost recovery. Commercial users radios would be

programmed only to authorized groups. The requirement for an electronic system to key to re-program a radio will prevent unauthorized groups from being programmed into any radio.

6.7.6 Changing Membership Category

There will always need to be the possibility of changing the status of members. For example, a small town may grow and decide to require the State to provide some additional facilities, thus switching from being a client member to an Integrated member. Each such change will have to be negotiated, and the particulars of each case will affect the way in which costs are divided or charged. General principles, however, should dictate that the agency initiating the change should bear a substantial part of the costs, that shared equipment and land should return to its original owner, and that sharing should be encouraged whenever possible.

Two problems will occur when an Integrated member withdraws from the system, leaving an area without coverage for the State users; obviously, a maximum amount of time should be allowed for such a change to occur. In addition, the change from a single system to two less-efficient smaller systems may require substantial additional funds to be expended by both parties. On the other hand, combining two independent systems into a single more efficient system may not result in immediate cost savings, because of the expense of reconfiguring systems and equipment.

6.7.7 Priority Use during emergencies

In addition to exact compliance to system protocols and data bases, the total system (state and member networks, alike) would be pledged to operate according to a pre-arranged set of priorities for certain scenarios. Under normal circumstances, of course, there would be adequate system capacity, and there would be no need to choose which users would obtain service. These priorities would occur only under very extreme circumstances. These circumstances could include Presidential visits, extreme natural disasters (Big Thompson Flood), riots, etc.

The use of priorities must be treated seriously; without them many of the Federal agencies (for example) will not judge the system sufficiently robust to rely on in times of stress. Lacking clear priority rules, these agencies will build their own independent, expensive, frequency-hungry systems, instead of participating in the Colorado statewide net. If they join the Colorado system, they will be able to pay for additional capacity, coverage, and robustness, which will be of great benefit to the other users during the 99.999% of the time when priorities are not required.

It should be noted that priorities are not merely “pulling rank.” Particular functions would have different levels of priority, depending on the nature of the emergency. These will be agreed to in advance, according to user inputs, and should represent the best judgment on how to employ vital public

communications resources during exceptional circumstances. During these circumstances, personal or bureaucratic convenience will be required to give way in the face of needs that have been judged more important to the public welfare. This means, however, that Cooperating members may very occasionally need to cede the highest priority to an outside user.

Priority use during particular events is in addition to the "emergency" button on most handsets, which is intended to raise the priority of an individual message in times of imminent personal danger. All use of priorities would require justifying circumstances; improper use would be subject to review and possible disciplinary action.

6.7.8 Construction funding and operating expenses

Client members expenses would include purchase of their own radios and, possibly, nominal annual users fees. Integrated members would need to pay a substantial share of the construction cost (the incremental cost of their part of the system), and annual fees for maintenance and the cost of providing service. Cooperating members and Associated members would pay for the cost of building and operating their own systems, though perhaps the State would contribute a portion of the cost savings from otherwise having to build a separate state network in a Cooperating coverage area. The State of Colorado would pay for building and operating the network infrastructure, including network management, and for the sites and radios needed to service the State Patrol, Highway Maintenance, Natural Resources, Corrections and other State agencies.

It will be expensive to manage a state-wide network, from the standpoint of managing the network day-to-day, as well as purchasing and implementing the dispatch and network management software and hardware. The administrative system controlling the entire network will be operated and administered by the State of Colorado. The State will enforce performance and reliability standards, so that users can be assured of receiving the needed level of service. This would include maintaining the daily database of what users are authorized across the network, the safekeeping of encryption keys and other restricted data, the operation of several dispatch centers, and the administration of the entire system.

The overall Colorado State network will be managed by the State of Colorado. In addition, the Integrated and Associated members will need to purchase, operate, and manage their individual local systems, which may be interconnected as parts of the State-wide network. The local member networks will require their own set of compatible hardware and software, dispatchers, databases, trunked base stations, etc.

Monthly operating fees might be assessed for use of the system. Presumably, site/network software would be available to allow user traffic to be measured. Some compensation might be required if a Cooperating or Associated system used much more or much less service throughout the State than it provided to

State functions within its own area. In many cases, services rendered would tend to cancel services consumed, and one might consider them balanced out without a “per-call” payment. Whether a per-call payment plan is initiated, traffic measurement functions will surely be used to give an estimate of system loading and for cost sharing.

6.7.9 Overall system architecture

The architecture of the state-wide system described above consists of:

1. a number of compatible trunked sites,
2. a network connecting and coordinating the trunked sites, and
3. an administrative system controlling the network.

Some of the trunked sites would be owned and operated by the State of Colorado, while others would be owned and operated by Cooperating and Associated Users. All sites would rigorously conform to APCO-25 standards and Colorado State conventions, as necessary.

The connecting network would be controlled by the State of Colorado. It would include microwave links, leased fiber, common carrier DS1, etc., as well as the software and hardware needed to coordinate the use of the multiple sites, the data bases of user authorizations and other data. In some cases, the Cooperating or Associated systems would be multiple-site systems connected with their own network, so the Colorado network would be a network of networks.

A user organization will provide long-term policy guidance to the State for the operation of the state-wide system. This group will ensure that the State hears member complaints, requests for new services, etc. The details of this organizations rights and obligations have not yet been determined.

6.8 TRAINING

One of the most important tasks in the implementation of the system will be training. There will be 3 areas where training will be required; system users, system management and system maintenance. All vendors providing equipment will be required to provide extensive training. The majority of the training will be “train the trainer” classes. This will provide the users with in-house trainers who can provide both initial and ongoing operational training. The State will also receive extensive system training and will offer training to those agencies who chose not to conduct their own classes.

7.0 STATE PATROL COMMUNICATIONS CENTERS

7.1 COMMUNICATIONS CENTER CONSOLIDATION

The Division of Telecommunications and the State Patrol have been developing a plan to consolidate the existing 16 communications centers into 5 regional centers. This planning effort has been in conjunction and as part of this plan to migrate to a digital trunked system. All of the console equipment installed over the last 8 years with the exception of Craig is capable of being upgraded for both the consolidation and the digital trunked system. The consolidation is tentatively planned to coincide with the implementation of the trunked system, however unknown circumstances may alter this consolidation implementation.

The final locations for the 5 regional centers has not yet been determined. Tentative locations are Denver, Pueblo, Alamosa, Montrose and NW Colorado. The final site selection will be determined using specific criteria such as access to the State microwave system, employee housing and potential spouse employment, workforce availability and facility availability. Selection will be completed for each location separately during the year preceding implementation.

Consolidation of the State Patrol centers will provide the capability for backup operation of any center from any center. Equipment for local dispatch positions will be installed in the centers that are closed for emergency and back up operations.

7.2 TRAFFIC OPERATIONS CENTER

The Colorado Department of Transportation (CDOT) has been developing a plan to implement Intelligent Transportation Systems (ITS, Formerly IVHS) throughout the State. The major emphasis has been in the Denver metro area. Both the Division of Telecommunications and the Colorado State Patrol have been participating in this planning effort. One of the key planning objectives in the establishment of a Traffic Operations Center (TOC) in the Denver area with future sites state wide. All 3 agencies have agreed that a combined communications center and traffic operations center can provide a significant operation efficiency as well as cost savings. The ability to share various forms of traffic, accident, weather and construction information will provide a higher level of services to the people of Colorado. All current planning efforts are to establish the TOC in the Denver regional communications center.

8.0 PROJECT SCHEDULE

The project schedule has been developed with several objectives in mind. The completion of APCO Project 25 standards is a major key in the schedule. In order to secure funding for each implementation phase it is imperative that the schedule be adhered to fully. Any delay in the planning and design phases will most like result in the delay of the implementation phase. Actual implementation is contingent on funding.

PROJECT TASK	SCHEDULE
Final users group reports	June 1994
Develop preliminary and marketing plan	July 1994 - December 1994
Legislative and cabinet informational meetings	January 1995
Develop preliminary technical system design	January 1995 - April 1995
Equipment procurement process	April 1995 - June 1995
Develop state funding request	April 1995 - June 1995
Non state agency commitments	June 1995 - August 1995
Phase 1 implementation	July 1996 - June 1997
Phase 2 implementation	July 1997 - June 1998
Phase 3 implementation	July 1998 - June 1999
Phase 4 implementation	July 1999 - June 2000
Phase 5 implementation	July 2000 - June 2001
Phase 6 implementation	July 2001 - June 2002

Each implementation phase will be on a regional basis. The region or areas may change depending on need and funding. The tentative areas for implementation are:

Phase 1 - Denver Metro Area

Phase 2 - Northeast Colorado

Phase 3 - Southeast Colorado

Phase 4 - San Luis Valley

Phase 5 - Southwest Colorado

Phase 6 - Northwest Colorado

A map showing the specific areas for each phase is located in appendix 12.7

9.0 SYSTEM COST AND FUNDING

Perhaps the most frequently asked question up to this point is how much will the system cost and where will the money come from. Early estimates have ranged from 60 -120 million dollars. The Division of Telecommunications, as the lead agency in the development of this plan, has tried to set these two questions aside. It is not because these questions are not important, but that the concept of planning and designing a system from the bottom up made the user and system operational requirements far more important. Now that this plan is completed, development of the financial plan for the system will be a priority for all participating agencies. One other reason that the system cost could not previously be determined is the APCO 25 compliant equipment is not yet being manufactured or sold. With the pending completion of the APCO 25 standards, several manufacturers are gearing up to market equipment and actual costs should be available in mid 1995 and APCO 25 equipment available in late 1996. The cost shown here are still estimates and will need further study before final budget figures are prepared.

Where will the money come from? There are several methods and possibilities for funding the system. The majority of backbone and fixed equipment costs will be the state's responsibility since they will be the largest user. The State is studying various funding methods and sources. These include 100% State funds, Federal grants, programs and matching funds, and a statewide referendum to establish a fee or tax. All of these methods are being explored and will be discussed with the Governors staff and State Legislature in early 1995. A statewide referendum may also include the funding for local government agencies. The final system cost and funding methods should be determined by May of 1995.

The cost of the system has 3 major components: backbone, subscriber units, and fixed equipment. The backbone includes repeaters, antenna systems, system interconnect equipment, new transmitter sites and the network management system. Subscriber units include the mobile and portable field radios used by all participating agencies. Fixed equipment includes dispatch consoles and control stations. Peripheral devices or subsystems such as mobile data terminals, computer aided dispatch systems or graphics display devices are not included in the system costs.

The majority of the system will use existing transmitter locations owned and operated by state, local or federal agencies. The existing State sites will be interconnected using the existing State microwave network which is being upgraded from an analog system to a high capacity digital system, in order to support the trunked radio system. The microwave upgrade project is being implemented and funded separately from this system. Approximately one half of the system has already been upgraded and the rest will be completed by the end of 1998. (A microwave system map is located in appendix 12.7)

New transmitter sites will be required where existing sites will not provided the required coverage. New sites will attempt to share existing sites and towers

owned and operated by private and commercial entities. There will be a need to establish new State owned sites where there are no other alternatives, but this will be the last option for providing high quality statewide coverage.

9.1 BACKBONE EQUIPMENT COST

The largest portion of the system cost will be the backbone. It is very difficult to determine the final backbone costs until the final engineering and system design completed and a vendor to proved the backbone is selected. For agencies that will be required to provide additional repeaters due to a substantial increase in the system loading, the individual repeater cost estimate of $15,000 should be used.

BACKBONE EQUIPMENT COST ESTIMATE

Phase 1 - $25,000,000
Phase 2 - $20,000,000
Phase 3 - $15,000,000
Phase 4 - $15,000,000
Phase 5 - $15,000,000
Phase 6 - $15,000,000
TOTAL - $105,000,000

9.2 SUBSCRIBER EQUIPMENT COST

Subscriber equipment cost includes the mobile and portable radios each agency will need to use the system. All equipment currently in use must be replaced These costs are the easiest to estimate, although the per unit cost is based on high tier non APCO 25 compliant equipment since APCO 25 equipment costs are not yet available. The quantities shown are for State owned units only. The use of APCO 25 equipment will allow for various vendors to provide subscriber equipment through a competitive bidding process. The competitive bidding process will include high, mid and low tier equipment, which will allow the user to select the most cost and application effective radio. Some users will not require high tier equipment and actual costs should be from 10% to 40% less for mid and low tier units..

SUBSCRIBER EQUIPMENT COST ESTIMATE

DESCRIPTION	COST PER UNIT	TOTAL QUANTITY	TOTAL COST
MOBILE RADIO	$2,800	6000	$16,800,000
PORTABLE RADIO	$2,600	4000	$10,400,000
TOTAL			**$27,440,000**

9.3 FIXED EQUIPMENT COST

Fixed equipment costs can be estimated based on the number of communications centers and how the consolidation will occur. The vast majority

of dispatch consoles that have been installed over the last 8 years can be upgraded to work with the new system **only if the same vendor is selected to provide the backbone**. If a different vendor is selected the console equipment in Denver, Sterling, Pueblo, Lamar, Trinidad, Hot Sulphur Springs, Eagle, Grand Junction, Montrose, Alamosa and Durango will have to be replaced. The cost estimate to replace these consoles is $2,000,000. The console costs shown, include the upgrades to the 11 existing consoles as well as the new console equipment necessary. Funding for the communications center consolidation may be funded separately. Other fixed equipment costs are estimates only and will have to be determine after the final system design is completed.

FIXED EQUIPMENT COST ESTIMATE

DESCRIPTION	COST PER UNIT	TOTAL QUANTITY	TOTAL COST
CONTROL STATION	$2,400	100	$240,000
CONSOLE UPGRADES	$120,000	11	$1,320,000
NEW CONSOLES	$150,000	3	$450,000
CONSOLE CONSOLIDATION	$120,000	5	$600,000
TELEPHONE INTERCONNECT	$60,000	5	$300,000
TOTAL			**$2,910,000**

The total System cost estimate is $135,000,000. This estimate is based on current equipment cost estimates, The Division of Telecommunications believes that it is within 10% of the actual system cost. Again until the final system engineering and design is completed and a vendor selected for the backbone, it is not possible to refine these estimates

9.4 AGENCY COSTS

The portion of the system that will be allocated to individual State agencies will be determined by what method and resources are used to fund the system. If the entire system is funded as a single budget item, there may not be any agency cost. If the traditional method of funding continues, each agency will be required to fund their own subscriber equipment and their share of the backbone and fixed equipment. Which method is used will need to de determined by consensus of the State agencies, the State office of Planning and Budgeting and the State Legislature.

It is the recommendation of the Division of Telecommunications to fund the initial backbone, subscriber and fixed equipment as a single budget item, within the Department of Public Safety or Department of Administration. This will help in obtaining matching funds from federal and other non state sources.

Local government agencies will be required to fund their own subscriber and fixed equipment. They will also be required to fund any additional backbone equipment necessary to handle the system loading increase, caused by their agency. The Division of Telecommunications will provide the information on

exact costs and loading impact. They will also help in identifying potential outside funding sources.

9.5 OPERATING COSTS

Estimating the ongoing operating costs for the system are probably even more difficult than estimating the equipment cost. The use of new technology including the network management and control system should enable the Division of Telecommunications to operate the new system for close to the same cost as the present system. New digital equipment is highly reliable and not subject to multiple failures. Subscriber equipment will have very few field repairable components which should also keep the operating cost consistent with the current system. The Division of Telecommunications annual expenditures for the operation of the existing system are just over 2.6 million dollars. This includes all fixed, subscriber, communications center, sites, towers and microwave equipment. Since the new system is very dynamic the operating cost at a single site or area is not easily identifiable. The Division of Telecommunications does not initially intend to change its annual operating budget until actual system costs can be determined. It will be very easy to accurately track the new system costs with the network management system. It may be necessary to revise the Division's budget once the actual cost are determined.

9.6 USER FEES

Fees to access the system are being considered for 2 reasons. The first is to provide a pay back mechanism for the initial system cost and the second is to fund ongoing system maintenance, management and upgrades. While there are no user fees being charged on existing systems, they are being explored for the new system. There are 2 variables in determining if fees will be assessed. If the initial funding does not require a pay back and if ongoing funding for maintenance and upgrades is provided from general fund money, then no user fees will be necessary. It will also be necessary to change the Division of Telecommunications and the Colorado State Patrol statutes to allow the users fees to be assessed.

The methodology for determining the users fees will be a monthly flat rate per subscriber unit. The actual rates have not been determined but early estimates range from $6.00 - $20.00 per month. The rate would be tiered with minimum rates being assessed for basic service and higher rates for advanced services such as telephone interconnect, data transmission and encryption.

10.0 SYSTEM MAINTENANCE

The primary responsibility for system maintenance will be with the Division of Telecommunications. As the primary management and control agency they will be able to monitor the status of the entire system, including local agency systems that are interconnected to the State system. The network management system will allow immediate reporting of any system failure or malfunction. Many problems will be reported and repaired without the users even being aware there was a problem. This is largely due to the built in system redundancy. The Division of Telecommunications has technicians on call 24 hours a day, operating from 13 locations in the state. These technicians are require to respond to system problems within 2 hours. They will all have the ability to access the network management system for their local shop or their own residence via laptop computer and modem. This will allow them to very rapidly determine the problem and take appropriate action. The Division of Telecommunications anticipates establishing a network control center where all of the different State operated networks will be monitored 24 hours a day. The control center will act as a central notification point for all system problems.

Local agencies that construct their own systems and interconnect them to the State system will be responsible for the maintenance of their systems. Arrangements for contractual maintenance of local systems by the Division of Telecommunications will be evaluated on a case by case basis.

11.0 ACKNOWLEDGMENTS

The development of this plan has taken many hours of intensive work by a large group of people. It would not have been possible for the Division of Telecommunications to develop a thorough plan without the assistance of the entire users group. The input, ideas and discussions of the users group thoroughly examined each aspect of the new system and the results are well documented. While it is impossible to name everyone, there are several people who provided exceptional services in the development of this plan. The Division of Telecommunications wishes to extend their sincere thanks and appreciation to everyone and especially to the following individuals:

Bob Matheson	NTIA
Bob Amick	University of Colorado
Linda Smith	Colorado State Patrol
Kathy Thomas	Colorado Department of Corrections
John Powell	University of California-Berkeley
Martha Morales	Division of Telecommunications
Tiffany Martin	Division of Telecommunications

USERS GROUP SUB COMMITTEES

STEERING COMMITTEE

Keith Conquest	El Paso County
Don Maser	Motorola
Marty Bain	City of Aurora
Ed Phelps	City of Aurora
Gary Mcknight	Durango Police Department
Ron Uthmann	Poudre Valley Fire Authority
Bob Leasure	Division of Wildlife
Linda Smith	Colorado State Patrol
Bob Matheson	NTIA

FUNDING AND FEES COMMITTEE

Randy Smith	Jefferson County Sheriff's Office
Al Reffel	Golden Police Department
Kris Venable	Wheat Ridge Police Department
Larry Stodden	Wheat Ridge Police Department
Kathy Thomas	Department Of Corrections
Tony Chianese	Loveland Light And Power

TECHNICAL COMMITTEE

Steve Linn	FCC
Bob Bonner	STI Communications
Gene Porter	West Metro Fire Authority
Charles Copley	Morgan County Communications
Janice Penfold	Morgan County Communications
Mike Slavick	Larimer County
Dave Balsick	Pueblo Mountain Communities

SYSTEM AND USER OPERATIONAL REQUIREMENTS COMMITTEE

Chris Childs	State Division of Parks
John Bredehoft	State Division of Wildlife
Steve Kabelis	Lakewood Police
Vicki Schenschek	Auraria Public Safety
Gail Matuszak	Estes Park Police
Ron Anderson	Loveland Police
Peter Gouge	Estes Park Police
Debbie Tellez	Ft Collins Police
Mary Moore	Loveland Police
Bob Amick	CU Boulder Police

12.0 APPENDIX

12.1 USER GROUP SUB-COMMITTEE REPORTS

System and User Operational Requirements Committee

Determine management, structure and maintenance based on user requirements

(KEY ASSUMPTION: There will be 800 MHz. - Vhf linking)

KEY ISSUES

1. Management of organizational structure
2. User group definition and span of control
3. Maintenance (user group - infrastructure)
4. Ownership and acquisition of equipment
5. Interfacing with: non-users, users, 800-Vhf
6. Capabilities and deficiencies - technical group

ISSUE 1. Management of organizational structure

OBJECTIVE: ESTABLISH A "STRAW MAN" STRUCTURE

STRATEGIES

1. Identify established organizational structure with strengths and weaknesses.
2. Identify geographical service areas within that structure.

RESOURCES

1. Steve Kabelis - Library/phone calls/homework
2. Mike Borrego - Provide current list and information

ISSUE 2. User group definition and span of control

OBJECTIVE: DEFINE USER GROUPS AND THEIR SPAN OF CONTROL

STRATEGIES

1. Develop comprehensive list of communication system users.
2. Recruit representative group.
3. Identify political/control issues.
4. Inform potential user groups of potential impacts on their agencies.

RESOURCES

1. Mike Borrego - for current lists
2. Mary Moore - informing/requesting groups

ISSUE 3. Maintenance (user group and infrastructure)

OBJECTIVE: define responsibility for maintenance of user group equipment vs. infrastructure equipment and the merger of the two

STRATEGIES

1. Need input from technical group; answer the following:
    1. Define what people are doing now
    2. Who will own equipment and will they maintain it?
    3. Regional/State contracting for service
    4. Who owns what now?
    5. What does the State plan on owning?
    6. What equipment will we need?

RESOURCES

1. John Bredehoft will check if another committee (technical) is already addressing.

ISSUE 5: Interfacing with users, non-users, 800-UHF

STRATEGIES

1. Ensure not duplicating efforts of another committee.

RESOURCES

1. John Bredehoft will check with technical and funding committees.

ISSUE 6: Ownership and acquisition of equipment

STRATEGIES

1. Ensure not duplicating effort of another committee.

RESOURCES

OPERATIONAL AND SYSTEM REQUIREMENTS COMMITTEE

SUMMARY REPORT

Mission Statement

A telecommunications system can only be effective if it is utilized on a broad basis by all levels of government (federal, state, and local, as well as the private sector when appropriate) to enhance the public safety function.

Current technology and system administration, utilized for public safety communications is characterized by an uncoordinated, localized or occasionally regionalized approach. A crippling aspect of present telecommunications policy (or the lack thereof) has been one of isolation as well as incompatibility of frequencies and equipment. Due a lack of system standards, and incompatible proprietary technology, jurisdictions which frequently interact due to immediately adjacent proximity are often incapable of direct intercommunications and coordination. Clearly, this deficit is sorely in need of improvement on a comprehensive basis.

Scarcity and inefficient utilization of frequencies has led the FCC and APCO, and subsequently the State of Colorado, through the Division of Telecommunications, to provide for an automated intelligence systems technological approach to communications equipment, and the implementation of a systematically designed and

administered telecommunications network

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The implementation of the APCO Project 25 Standards for digital trunked radio systems, and the concurrent development of the State of Colorado Digital

Trunked Radio System, represents a futuristic approach to utilization of emerging technology to provide optimal public safety services for the people of Colorado.

Every effort must be made to afford resources and opportunities for participation by public safety providers at all levels and geographic areas. Rural and wilderness providers have many challenges not faced by their urban counterparts; conversely, urban providers have unique challenges not present in the rural-wilderness environment. Each must be satisfied to preserve public safety throughout the state.

A comprehensive telecommunications system serves as the control and coordination "backbone" resource to effectively link public safety functions in an unprecedented network. Maximum effort must be expended to ensure that intergovernmental cooperation, legislative and financial support are directed toward full implementation of this most vital project.

Introduction

Through the following outline, we hope to communicate many of the needs expressed to the committee members by the radio users we have talked to around the state. An effort was made to talk to representatives of all agencies that might someday want to participate in a statewide Colorado digital trunked radio system. Although this document is not a completely definitive list of the requirements for the state's system, it may help insure completeness in the engineering committee's efforts, and may help future participants in the system to understand its purpose.

The authors are grateful to all members of the System and User Operational Requirements Committee for their time and expertise in contributing to this report. The input from user group representatives from throughout the state who contributed via surveys and discussions is also gratefully acknowledged. Future revisions of this document are dependent on further review and input from committee members as well as user-group representatives.

Definitions

1. Conventional - refers to non-trunked non-digital systems in heavy use in much of the

   state today. There is no implied reference here to compliance with FCC Docket No. 92-235.
2. Participating - refers to users and agencies that will operate equipment and that will use equipment designed for the statewide system and using digital trunked technology.
3. Non-Participating - refers to users and agencies using only conventional UHF/VHF equipment, or newer technology equipment that is incompatible with the statewide system; Also refers to the equipment.

4. Talk-Groups (talk groups) - Refers to a logical grouping that allows its members to communicate distinctly from other users of a digital trunked system. A talk groups functions much as a radio "channel" does in conventional systems, however, its application bears no resemblance. talk groups are typically owned or governed by a particular agency. Other agencies may be users of that talk groups by agreement. (Talk groups may be designated as local, regional, or statewide depending on user needs. In some cases, talk groups may need to be interstate when interaction with adjoining state jurisdictions becomes necessary).
5. Units - Refers to the equipment package that will, under the new system, replace current base, mobile, and hand-held radios.
6. Unit-to-Unit - Refers to communication primarily between two individuals. The individuals may be using base-station, mobile or hand-held equipment. The ability of other users to listen-in on the communication may or may not be implied.

General System Capabilities

1. System Flexibility

   The respondents have expressed a need for flexibility in the following areas, often requiring field configuration to adapt to the wide variety of situations and needs.

   a. Repeater and Non-repeater operations
   b. Full duplex (simultaneous transmit & receive)
   c. Concurrent Data and Voice capabilities (e.g. System should be interfaced with CCIC/NCIC) Note: Can terminal emulation be used on PC? What if CCIC is down for maintenance?
   d. Easily configured talk groups for intra-agency and inter-agency/multi-jurisdiction operation/coordination (note: non-dynamic regrouping during emergencies should be pre-planned with the use of icons on terminal screen).
   e. Widely configurable talk groups, some very large, including hundreds or even thousands of units, and some very small (maybe only two units).
   f. Local and Wide area talk groups. Wide area talk groups would allow users in widely separated parts of the state to communicate with each other.
   g. talk groups and individual paging on a state-wide basis.
   h. Many users certainly need to monitor talk groups that they would not normally be allowed to transmit on (e.g. highway dept. monitoring incidents that may require their assistance or cooperation; however, interagency communication and mutual aid capability should be provided for; such as direct communications between a snowplow

operator and a CSP Trooper coordinating a highway emergency or event.)

i. Equipment must be capable of using both Data and Voice encryption technologies (note: encryption is included in APCO 25 specifications as a standard feature; not an option)

j. Some talk groups will need to be usable, continuously, across large geographic areas.

2. Basic Functionalities:
   a. voice dispatch
   b. car-to-car voice
   c. car-to-car data
   d. data dissemination from dispatch centers
   e. paging (digital and voice)
   f. wireless portable/personal computer and fax modem support
   g. local system interconnect for early warning systems.
   h. emergency call box handling

3. System Interconnectivity for coordination and mutual aid:
   a. Linking trunked digital to conventional analog networks. Almost all users need to be able to connect to conventional systems to communicate with those agencies that for whatever reason will not or have not converted to a digital trunked system. Some of those agencies are located in states adjacent to Colorado.
   b. Telephone interconnect capability:

      Users also want connectivity to public tel-co and departmental PBX telephones systems including receiving transferred calls from comm-centers and establishing connections (i.e. dialing) from field units. When channels are available, and not needed for priority traffic on primary talk groups, interconnect capability should be available with the stipulation that it becomes subject to interruption when saturation levels are reached. Technology should include automated or manual monitoring of user “buildup” on the system, to avoid unnecessary risk of overloading the system. A site manager (or an automated monitoring system) can initiate an overload warning and automated “scale-down” of interconnect traffic to give priority to regular trunked radio traffic when necessary (e.g. pre- recorded message inserted into active interconnect conversations: “attention interconnect users- due to priority traffic you will have 30 seconds to terminate calls in progress before system disconnects.”)
   c. NLEEC availability:

      To accommodate all users of NLEEC (National Law Enforcement Emergency Channel) whether on conventional analog (VHF or UHF) or

digital trunked radio, a series of "tone-to-tone" hookups will be needed to permit coordination between user groups.

d. Compatibility with existing specialized equipment:

Users want compatibility with existing specialized equipment such as ear and throat microphones, motorcycle headsets, etc.

4. System Coverage:

a. Propagation/penetration requirements

Many users operate in remote mountainous terrain or deep in concrete and steel buildings where signal propagation can be a problem. Current systems design proposals allow for 90% coverage 90% of the time statewide. For some areas this level of coverage represents a significant improvement, for others, it may not be adequate. A higher percentage of coverage overall may be cost prohibitive (e.g., raising statewide ceilings to 95% coverage for 95% of the time). In metropolitan areas and particularly in institutional facilities such as college campuses, hospitals and prisons, coverage's of necessity may need to approach 99% or better. Mike Borrego indicated that some actual applications/installations have demonstrated better results than computer projections predicted (e.g., Washington State DOT installed an 800 MHz trunked system which has far exceeded computer modeling projections for propagation in mountainous, terrain due to unanticipated "reflections" from canyon walls and rock faces. That particular trunked system actually has exceeded performance of older VHF analog system. The Technical committee will need to determine whether the system will function using totally 800 MHz technology for both mountainous and flat terrain, or whether a mix of VHF and/or UHF trunked systems will be necessary along with the 800 MHz "backbone" system.

Larger jurisdictions with mountainous as well as flat terrain may elect to establish their own VHF trunked networks for regional applications (e.g., Boulder Regional Communications Center serving nearly all agencies in Boulder County) which then may be interconnected to the State system.

TASK ASSIGNMENT: The Operations/User Group Committee should determine what expectations are for user groups in all affected areas. One suggestion would be to query each affected geographic area (e.g. by county/service area) to determine expectations from users for geographic coverage as well as penetration/propagation characteristics.

5. System Reliability

a. Fault tolerance and buffered transmission feature

System needs to be fault-tolerant. Individual hardware pieces will fail; these failures should not impact the operations of the system assuming they are repaired in a timely manner. The system architecture should also provide considerable fault tolerance. Improved performance should be expected due to automated features of "smart radio systems" which will deploy adjacent repeaters in other sites to maintain talk groups at optimal levels. Time lapse required for system to acknowledge a request for an "open channel" from a user, assign a channel and link into the appropriate "talk group" is about .5 seconds or less in normal operations. Although a "talk-permit" tone is a standard feature of trunked radio to signal the user when a channel is "open" for transmissions, this characteristic can be a hazard in public safety use. For example, practical experience has shown that police officers tend to key the microphone and begin speaking almost simultaneously, especially under adverse situations. Such volatile conditions require rapid and highly reliable top priority communications capabilities. It is recommended that a "buffer" storage capability be built into portable and mobile radios which instantly accepts the voice transmission, digitizes it, and sends the full message as soon as a channel is provided by the system. If the transmission is a "life-safety" top priority message, (e.g. "police officer needs help, shots fired") some means of encoding the transmission to top priority status should be provided for eligible public safety providers. Mike Borrego has indicated that he will refer this proposal for inclusion in the APCO 25 specifications and/or inclusion in the Colorado trunked radio "standards based" system. (UPDATE: Mike has indicated that it may be too late to include buffering in the APCO 25 proposals, but could still be recommended as a future enhancement, particularly to the vendors for a standards-based system.)

b. System maintenance must not affect operations.

System needs to provide reliable, clean, interference-free communications. There should be no interruptions or degradation of service when routine maintenance is being performed. Redundancy or "fault-tolerance" should allow for scheduled maintenance as well as system failure, and switch automatically to alternative facilities. Catastrophic failures due to natural hazards or other unanticipated events should also be anticipated as addressed in item 7, below:

6. System Capacity

It should be understood that trunked systems by their nature provide a much higher capacity for communications than conventional systems. In light of this fact, what are the projections for users' needs that will outstrip this additional capacity?

a. The possibility of more directed and 'private' conversations, may create a use that has primarily been satisfied by telephones today.

b. The possibility of long haul (cross-state) communications will add additional burden on the system.

c. By far, the largest impact on the new system will be the need for data transmissions between dispatch centers and field units (such as wireless personal computer terminal modems for data exchange such as digital data queries, faxes and interactive crime reporting.)

7. Catastrophic or Major Event Impact on Communications Systems

a. Communications Systems must be designed to resist impact of catastrophic events (e.g. natural hazards such as earthquakes, floods, wildfires, tornadoes, hazardous materials incidents, etc.)

Communications systems have been shown to be vulnerable to natural hazards such as floods, wildfire, tornadoes, earthquakes, etc., and tend to fail when they are most urgently needed. Experiences in the recent mid-west floods and California earthquakes and wildfires have painfully reminded public safety officials of the vulnerability of communications systems which are not designed with several layers of "redundancy" or "fault-tolerance." A "devil's advocate" review of system reliability should be conducted by experienced emergency management and engineering personnel in a "table-top" exercise. Such an exercise would serve to answer most "what if..." questions that might not otherwise be considered in normal system planning. By providing several layers of redundancy in the system design, and adding "fail-safe" features, the reliability of a system can be greatly improved. Localized system failures due to site or equipment damage or loss can be automatically compensated for by automated switching to adjacent sites. In extreme cases with wide area failures, a mobile or portable emergency backup system could be brought in to serve the area until service of the permanent system can be restored.

b. Management of Mass Events

Mass events affecting multiple jurisdictions or service areas include regularly scheduled athletic competitions or celebrity entertainment where attendance may approach 100,000 in metropolitan areas. Unusual events such as the hosting of international celebrities or heads of state may result in substantially higher attendance and resultant impact. A recent example was the "World Youth Day" event of August, 1993, that was attended by nearly 400,000 youth and visitors from throughout the world, as well as the Pope, the President, and many international dignitaries and heads of state. Despite unanticipated demand for emergency medical services which

exceeded maximum projections by tenfold, the communications system was not challenged. This event was handled by two permanent and one special trunked radio system. Statistics on system use and impact during this event from the various agencies indicated a transmission volume over 100,000 messages on peak days which utilized less than half of the capacity of the system at peak intervals. Conventional non-trunked systems would have been overwhelmed by such loading due to lack of automated channel management afforded by trunking. System design should include capacity and reliability to network with all appropriate agencies to effectively coordinate such events.

c. Options for System Development and Enhancement

Sharing of existing sites becomes increasingly important to enhance redundancy, reliability, and effective propagation/penetration. It is far more cost-effective to install trunking equipment on developed sites shared between federal, state, and local government agencies, as well as the private sector providers should be legislatively provided for. Grant programs and coordination/technical advice should be pursued from Federal agencies (e.g. the Federal Emergency Management Agency or FEMA; and the Department of Commerce/National Telecommunications and Information Administration). Future expansion through satellite links should also be anticipated when/if technology becomes cost-effective and/or feasible.

Dispatch and Communication Centers

1. Administration of Systems

a. Agencies definitely need control of their talk groups. It should be understood that while some agencies are geographically bound (e.g. Ft. Collins PD) other are not (e.g. Colorado State Parks). talk groups need to be rapidly re-configurable. In emergency operations, new field units may need to be added to talk groups that were not planned for in the engineering of pre-plans.

b. Define and limit the number of talk groups usable by each agency.

This prevents a particular agency from saturating the system and preventing access by other users.

c. Administrative help from the state will be needed for smaller agencies that ordinarily do not have a need for personnel proficient in administering the system.

2. Operational Characteristics

a. Provide supervisory capabilities to prevent misuse of private trunks

b. Provide system utilization data to monitor the system loading in real-time.

c. Provide system and field unit utilization history.

d. Provide lockout for malfunctioning or illegal field equipment.

e. Provide user-friendly diagnostics, designed for dispatch personnel, not just system technicians.

f. Dispatchers must be able to configure simultaneous broadcast over multiple talk groups within the agency and the talk groups of other agencies by agreement. These talk groups may or may not be geographically local. The voice source may be within the comm-center or may be from a field unit, or some other comm-center.

g. The logical control point for activation of emergency public warning systems is in dispatch centers. Warnings initiated by one center must be easily disseminated to geographic areas affected by the hazard, as well as to other centers which may have adjacent warning and response authority.

3. Documentation and Recording of Transactions

a. All digital/analog communications (voice or data; encrypted or non-encrypted) must be documented/recorded for legal/liability and statistical analysis/management purposes. (This includes unit-to-unit field transmissions in various talk-groups which would not normally be monitored by a dispatcher in a Communications center. Another issue to be resolved is whether interconnect transmissions could or should be recorded).

b. Trunked radio systems present a particularly difficult challenge for recording due to the automated channel management protocols. The emerging technology of digital voice/data recorders shows promise in being able to transcribe/record such transactions: However, considerable analysis should to be applied to determine how administration/storage and security of such data will occur.

c. Recommendation:

1) Develop standards-based technical specifications for digital documentation/recording of voice/data transactions on trunked radio systems.

2) Develop administrative policies/procedures for management and security and storage and storage of such documentation by service area administration boards.

4. Encryption

a. APCO Project 25 standards provide for encryption of data/voice transmissions when necessary. A major failure of present analog systems is the provision of protected/secure communications for sensitive information. It is anticipated that with the inclusion of encryption as a standard feature for digital trunked radio, user groups will be increasingly disposed to utilize encryption when secure operations are necessary. Agencies which have utilized encryption extensively have received considerable pressure from news media (which typically monitors public safety communications on "scanners") to discontinue encrypted messaging and/or to provide the media with some kind of "licensed" access via monitors capable of receiving encrypted messages.

b. Implementation of encrypted voice/data transmissions in various talk groups should be easily accomplished through automated and/or remotely initiated commands to appropriate units.

c. Documentation/recording of encrypted transmissions for voice or data transmissions may present a challenge to system administration unless provisions are made for automated decoding/recording of such transmissions in the appropriate administrative service authority communications centers.

Field Operations (Mobile)

1. Data Support Capabilities:

Mobile units must have high speed data interfaces providing connectivity to multiple digital devices that could be installed in mobile environments. Examples of such devices are:

a. Fax machines
b. Mobile/portable wireless modem interface data terminals
c. Printers
d. Automatic vehicle location systems
e. Automatic Finger-print Identification systems
f. Vehicle Management Systems
g. Digital interactive (two-way) video/audio support

2. Voice Support Capabilities

a. Compatibility with conventional units
b. Digital storage of received audio for later playback

c. Alternate audio interface for relaying of previously recorded audio to a base (dictation for later transcription)

d. Car-to-car simplex communications

e. Car-to-car communications with use of repeater or relay.

   This implies communications between any participating units in the state

f. Implement mobile unit as mobile repeater/relay for portable units..

   This needs to work in the primary sense of the mobile unit relaying transmissions from a hand-held unit and also in the secondary use of relaying transmissions from a base to a hand-held unit which is local to the mobile unit, but cannot receive the base unit. (Note: this requirement is impacted by system propagation/penetration design characteristics; i.e., if fixed site coverage is sufficient even in remote/wilderness areas for portable radios to function when needed for back-country rescues or other public safety functions, then mobile relays and repeaters may not be necessary. Otherwise, portable/mobile trunked radio repeater systems may need to be developed for deployment in isolated areas which will temporarily support such operations. Such portable/mobile systems would need to provide many of the same interconnect/linking functions as fixed stations, or provide access to fixed stations with those capabilities.

g. Receive & display Auto-Identity information for voice communications

Talk Group Prioritization (talk groups)

Overview:

Talk Group Prioritization (talk groups) is defined in terms of the priority for use of the system by various user groups. The following system of Talk Group Prioritization is recommended:

A. Levels of Priority Defined

I = First (highest) priority:

(Suggested use): Life Safety top priority access for first responder public safety officers (e.g.,. law enforcement, fire, medical, et al) to Central Communications Centers for control and coordination of life safety priority emergent requests/responses (e.g., “officer needs help, officer down, shots fired, etc.).

Secondarily, control and coordination of local emergent events with priority-life safety and property threats that require emergent or urgent response (e.g., large vehicular accident involving hazardous materials/fire/injuries). Such events are considered “average” emergent responses for local jurisdictions, and seldom require unusual public alerting/warning or wide-area response coordination, with rare exceptions.

II = Second Priority:

Suggested use: control and coordination of catastrophic disaster events with massive life-safety and property impact (e.g., a large natural disaster affecting multi-jurisdictional and/or governmental boundaries such as Federal, state, and local Government, and also the private sector. Priority for such use is justified due to the significant and broad-based risk to life and property. Responsibilities include public warning and evacuation over large geographic areas. (examples: large earthquake, large wildfires, widespread flash flooding, hostile attack, et al.) Function includes warning and evacuation, coordination and control of emergency management operations through Emergency Operations Centers (EOC), and Incident Command Systems (ICS). Immediate response as well as long-term response and recovery control operations and coordination would be a function of the system (priority use would revert to lower levels during recovery phases.)

III = Third Priority:

Suggested use: Control and coordination of localized disaster events with significant life-safety and property threats (e.g. a moderate natural disaster such as a flash flood, wildfire, earthquake, or multi-jurisdictional response to major crimes such as a terrorist incident, sniper or automatic weapons assault, et al.)

IV = Fourth Priority:

Suggested use: Control and coordination of routine public safety events requiring non-urgent response on a local basis.

V = Fifth Priority:

Suggested use: Control and coordination of governmental operations involving non-urgent routine responses and data management, interconnect functions, etc.

VI = Sixth Priority:

Suggested use: Control and coordination of non-emergent communications for non-governmental and auxiliary user groups; private sector interface, et al.

Talk Groups Defined

Talk Groups defined by local, regional, and statewide/interstate use

Overview:

Talk Groups are defined by user group needs. A typical local talk group might include a geographic area defined by the city limits (or slightly beyond) of a city

or town. A regional talk group might include multiple jurisdictions within a county (e.g., several cities, towns, county government, and interactive agencies on a federal, state, and local level (e.g., State Patrol, Division of Wildlife, FBI, highway maintenance, parks, et al). The geographic "service area" Public Safety Communications Center (which customarily provides system access to the public for enhanced 9-1-1 service, and controls/coordinates the dispatching of public safety responders in that service area) would define the local, regional and statewide/interstate talk groups needed to provide comprehensive communications services to that area.

A statewide/interstate talk group might enable an authorized user to communicate with units of his own agency throughout the state (e.g., State Patrol, Division of Wildlife, State Parks, et al). State, regional, and local user group agencies would also be able to interconnect with agencies in adjoining states which may border their jurisdictions Additionally, local jurisdictions may be provided access to statewide talk groups in specific applications; For example, a sheriff's deputy transporting a prisoner from northwest Colorado to Canon City would be able to continuously access his/her home Communications Center in Craig, as well as any number of Communications Centers which serve the areas the deputy is passing through on the way to Canon City. If that officer requires assistance at any time during the trip, (s)he is never out of reach of either his/her home jurisdiction, or the jurisdictions through which (s)he is passing. The officer may be able to directly access the Corrections facility which is the ultimate destination.

RECOMMENDATIONS:
The User Group/Operations Committee should provide a survey of existing and proposed local, regional, and statewide/interstate communications centers to determine parameters for establishing number and type of talk groups. From this survey, a delineation of the number and type of talk groups necessary for each "service area" communications center could be developed.

Talk Group Classification
Overview:
Talk Groups are classified, as noted above according to use on local, regional, statewide/interstate categories. Within these categories are subsets of user groups which have been defined by the committee according to function. The committee assumes that within the general categories listed below, would be layers of different jurisdictions (e.g., federal, state, local, and in some cases private sector.) The following model is a suggested format for establishing talk groups according to those categories. The committee recognizes that some tailoring and modification of structure will be necessary for each "service area" or jurisdiction to meet specific local, regional, or statewide needs. However, in order to determine an approximation of number of talk groups necessary to be

established for the comprehensive system plan, the model serves as a starting point.

FUNCTIONS	AGENCY	COUNTY	REGION	STATE	INTERSTATE
SPECIAL EVENT/SITUATION	1	1	1	1	1
LAW	1	1	1	1	1
FIRE	1	1	1	1	1
E.M.S.	1	1	1	1	1
SEARCH & RESCUE	1	1	1	1	1
MUTUAL AID & TACTICAL	1	1	1	1	1
WORK/UTILITY/MAINTENANCE	1	1	1	1	1
ADMINISTRATION/MANAGEMENT	1	1	1	1	1

Mutual Aid Networks/Channels

Existing mutual aid channels/networks are dispersed among different bands (vhf, uhf, 800 MHz) according to service category of law, fire, EMS search and rescue, and federal/state/local jurisdiction. It is necessary to consider these existing channels, and to determine appropriate digital trunked radio complementary channels and networks which will interface with them, and/or eventually replace them.

EXISTING MUTUAL AID NETWORKS/CHANNELS

LAW

N.L.E.E.C (1 VHF) nationwide analog channel 155.475 MHz

C.L.E.E.R. (1 UHF) eastern front-range coordination for metro areas

FIRE

F.E.R.N. (3 VHF) nationwide analog channel 154.280 MHz., et al

AIRNET (1 VHF) airborne fire suppression net (U.S.F.S?)

WORKNET (1 VHF) regional wildland fire suppression (U.S.F.S.?)

E.M.S.

12 E.M.S. (UHF) CHANNELS (nationwide authorization) for ambulance to hospital, hospital to hospital, etc.

2 H.E.A.R. (Hospital Emergency Administrative Radio) VHF channels 155.280, 155.340 MHz, plus other special emergency channels (vhf, uhf) in various areas.

MOUNTAIN SEARCH & RESCUE/SKI PATROL

M.R.A. (1 VHF) nationwide use for mountain search and rescue and volunteer

National Ski Patrol coordination (155.160 MHz)

5- 800 MHz MUTUAL AID CHANNELS (UNDESIGNATED USE?)

STATEWIDE ALERTING/INFORMATION NETWORK

Overview:

Users have expressed a need for an efficient statewide alerting network which provides automated informational updates via voice and/or alphanumeric paging, wireless modem "palm-top" units, etc. A significant problem which occurs in virtually all jurisdictions is non-communication between different agencies which may work in a particular geographic service area, but be dispatched by a different communications center (e.g., the U.S. Forest Service may have a ranger working in a law enforcement situation requiring 'cover' for an uncooperative suspect.). His service area communications center may be remote from the primary public safety communications center. Therefore, unless (s)he has direct access to the primary public safety communications center channels in the service area where (s)he is working, the officer's own dispatcher is the only link to the other center for initiating mutual aid assistance. There might very well be a wildlife officer within five minutes travel time of the forest ranger, who is not alerted to the mutual aid request. The communications center relies on normal protocol to send a Sheriff's deputy who may be much further away. Similarly, a State Patrol unit might be closer, but because of protocols, the communications center dispatcher may not opt to ask for mutual aid from CSP communications center, even if their car just happens to be much closer. However, if either the State Patrol or Wildlife Officer has the public safety communications service area operations channel programmed into their units, and IF they are scanning and happen to hear the call, they may elect to respond on their own. Often, however, this does not happen. Therefore, what is needed is a comprehensive alerting system which can quickly and comprehensively deliver such information to a wide variety of public safety officers in all jurisdictions ranging from federal, state, and local who may have occasion to work in the particular service area.

Concept of System

This network would provide "B.O.L.O." (be on the lookout for...) information on wanted persons, suspect/vehicle information, major emergencies/events in various regions, etc. The system would be an extension and/or expansion of the current CCIC/NCIC B.O.L.O. or regionalized network messaging systems (e.g. "metro, crime, I-25, I-70," etc.). Too often, information which could be useful to

various agencies/jurisdictions falls “through the cracks” in terms of dissemination, either because it is not transmitted by a dispatcher when it is received from a CCIC terminal, or because if it is transmitted, it is only done on certain channels which users in a given area do not monitor. If a dispatcher can simply draw a “polygon” or box on a computer assisted dispatching (CAD) screen around the geographic area where the mutual aid is needed, then any car/unit from any jurisdiction which is equipped with this alerting network will be simultaneously notified of the request, and can notify the communications center of their location/availability to respond. (It may be that if Automatic Vehicle Locator (AVL) systems are implemented, the availability of all public safety units in a given geographic service area will be displayed for the dispatcher much as an aircraft transponder “squawks” an identification code and location point to the Communications center AVL mapping display. Therefore the location of all available public safety units who could respond is instantly displayed and recommended to the dispatcher who may then pick the computer’s recommendation, or override and send other units. The advantage of this type of network is that information can be sent out in large volumes, stored in a message buffer for the receiving unit, and addressed by region so that all users having need to access the information can be rapidly alerted. Priority alerts such as pursuits, armed robberies, hazardous materials incidents, “officer needs help” mutual aid requests, could be programmed and transmitted by “polygon” or regionalized computer mapping to all appropriate layers/jurisdictions in areas which are potentially affected by the alert. An alert tone/light can be activated for priority messages on the receiving units when officers need to be instantly advised of urgent events. “Fax-type” printouts of the information can be generated on palm-top wireless modem radios when needed, including photographs, maps, diagrams, fingerprints, etc. A significant advantage of this network is that it does not “clog” voice channels with vast amounts of information which preclude use of the channel for emergent radio traffic, and yet public safety officers can easily be kept informed of all pertinent events in their jurisdictions. The network can easily be expanded to other categories beyond law enforcement, including fire, E.M.S., search and rescue, utilities/maintenance, administration, etc. Access to a variety of information such as CSP road condition reports, national weather service weather warnings, meteorological data such as storm cells, wind, fire danger, avalanche danger, etc., could easily be linked into the system.

Field Operations (Base)

This refers primarily to remote base stations such as PD annexes, Fire Stations, Park Ranger offices, etc. The functionality of mobile units applies here also. In addition:

a. Integration to Intelligent Facilities Systems
   i) Station Door Operation
   ii) Vehicle Bay and Outdoor light operation

Field Operations

Emergency Outdoor Telephone System

(System Entry Access To Central Communications for the Public)

Overview:

Emergency System entry access by the public to central emergency communications centers for emergency assistance is often difficult in remote rural areas and urban highways due to lack of available and easily identified emergency telephones. This deficiency is often the result of a lack of communications facilities (e.g. phone lines/radio system, etc.) to support emergency access. Cellular Service is often not available in isolated areas due to low subscription potential, and does not presently lend itself to ANI/ALI recognition. A statewide network of emergency outdoor telephones is essential to obtaining emergency help rapidly and reliably. In many areas, it is not practical to install wireline or cellular-based emergency call boxes. Since all emergency call box use must be directed to a dispatch center, utilization of a digital trunked system is an appropriate and logical application. (Mike Borrego has indicated that FCC approval for use of trunked radio frequencies in callbox applications may not be permitted. A special use application may have to be requested in order to implement this recommendation, or other frequencies identified which permit emergency outdoor callbox applications.)

A. Basic Functionality:

1. Voice capability
2. Caller ID (ANI/ALI)
3. Call Back, by dispatch or other field units
4. Standardized, vandal-resistant, well-marked, illuminated units (flashing blue strobe) and overhead safety lighting (h.i.d. metal-halide or h.p.s. luminaires)
5. Solar-powered battery-operated units in remote areas.
6. Public education campaign to familiarize public with availability and use of system
7. Future consideration of digital interactive video from site of callbox

Field Operations

Emergency Medical Services Support

Overview:

Emergency Medical Services (EMS) is a major component of the system requiring networking as well as regional control and coordination of services. Many rural areas of the state have inadequate communications for EMS systems allowing for comprehensive patient reporting, consultation with physician advisors, connection with major trauma centers (level I, II) and aeromedical evacuation and coordination. A trunked radio system design should evaluate the deficiencies and needs of EMS, and provide for effective control and coordination. Some of the concepts suggested for EMS include live color interactive video/audio conferencing between hospitals and field paramedics, vital signs telemetry (e.c.g., e.e.g., blood-gas analysis/pulse oximeter, wireless modem palm-top communications, differential diagnostics linking with trauma center computers, etc.)

Recommendations:

1. Consult with State Health Dept., EMS office and EMT Association, Physician advisors, trauma centers, et al, to develop comprehensive system needs, propagation and penetration studies, future expansion.
2. Develop features similar to those specified for other public safety components which allow for interactive communications, control, and coordination, and provide a system architecture or platform to support emerging technologies.

Field Operations

Warning and Evacuation Notifications

(Wide-area delivery of emergency warning and evacuation information)

Overview:

The delivery of wide-area emergency warning and evacuation instructions and information to the general public concerning natural and man-made hazards (e.g. flash floods, tornadoes, hazardous materials incidents, etc.) has long been a weak point of emergency management. A number of behavioral characteristics exemplified by the public in disasters has been documented:

1. Outdoor warning sirens are seldom heard inside buildings or in vehicles.
2. The public often ignores warning sirens, if they do hear them, because they do not understand what they mean, or assume that they are a “drill” or a “test.”

3. The public has an inordinate need to verify or confirm warnings which may affect them directly due to a denial or rationalization process. (e.g., "It will never happen to me; if it does happen, it won't affect me; if it does affect me, it won't be that serious; if it is that serious, there is nothing I can do about it anyway").
4. The public will respond to messages directed specifically to them by an authority figure whom they know and associate with their surroundings.
5. A comprehensive community disaster preparedness public education and awareness campaign, when coupled with an effective directed warning system, can be highly effective in preventing significant loss of life and injury.

Recommendations for implementation:

1. Current technology is available to link Communications Centers with local telephone and PBX switching networks which allows high-speed multiple and simultaneous delivery of warning and evacuation instructions to specific "blocks" of residents. Those individuals who may live in affected areas (e.g. a flash-flood warning or hazardous materials incident) requiring "in-place" sheltering and/or evacuation for a specific population area can be identified on "GIS" or similar mapping systems. By using a pre-identified telephone subscriber data base, individually tailored messaging can be delivered to each affected resident. Pre-recorded messages, even for non-English speaking or hearing impaired persons (TTY/TDD) can be effectively delivered, and receipt of the message can be recorded or retried later, if the resident is not home.
2. Since public safety communications centers typically are charged with rapid activation of public warning systems, inclusion of this component of emergency management logically falls within the parameters of system design and support. This becomes increasingly important as communications centers are consolidated and regionalized (e.g. a regional communications center (county or CSP) might have responsibility for initiating a warning for a remote mountain or rural plains community hundreds of miles away). By having pre-programmed "blocks" of telephone numbers associated with the affected area, in a data base, effective and remote delivery of rapid early warnings is easily accomplished.
3. Close cooperation and coordination with emergency management officials at Federal, state, and local levels, as well as liaison with local emergency management councils (coalitions of public and private organizations) is necessary to implement and administer this technology.
4. Interfacing with other warning systems:

(NOAA/NWS weather radio just announced expansion of coverage areas and warning capabilities to an "all-hazards" status which permit regional communications centers to initiate warnings on that network. Other similar applications may be forthcoming in the near future.

Field Operations (Hand-Held)

1. *Data Support Capabilities:*

Data needs for hand-held units are few but might include:

b. Alpha-numeric paging
c. Interfaces for ADA equipment
c. "Palm-top" (wireless modem) hybridized voice/data terminal

2. *Voice Support Capabilities:*

a. Compatibility with conventional units
b. Digital storage of received audio for later playback
d. Simplex car-to-car communications without use of repeater or relay
e. car-to-car communications with use of repeater or relay.
(this implies communications between any participating units in the state)
f. interact with mobile as relay/repeater
(this needs to work in the primary sense of the mobile unit relaying transmissions from a hand-held unit and also in the secondary use of relaying transmissions from a base to a hand-held unit which is local to the mobile unit, but cannot receive the base unit)
g. Receive & display Auto-Identity information for voice communications
h. "Emergency/Officer Needs Help/Officer Hostage" alarm signal button/key activation feature.

3. Environmental Capabilities:

a. Portable and mobile equipment shall (when necessary) meet requirements for intrinsically safe operation for hazardous materials/explosive atmospheres, (e.g. NFPA/MSHA/OSHA/MIL spec., et al) and wet environments.

SUMMARY OF OPERATIONS COMMITTEE FOLLOW-UPS

Recommendations:

1. Consult with State Health Dept., EMS office and EMT Association, Physician advisors, trauma centers, et al, to develop comprehensive system needs, propagation and penetration studies, future expansion.
2. Develop features similar to those specified for other public safety components which allow for interactive communications, control, and coordination, and provide a system architecture or platform to support emerging technologies.

The User Group/Operations Committee should provide a survey of existing and proposed local, regional, and statewide/interstate communications centers to determine parameters for establishing number and type of talk groups. From this survey, a delineation of the number and type of talk groups necessary for each "service area" communications center could be developed.

1) Develop standards-based technical specifications for digital documentation/recording of voice/data transactions on trunked radio systems.
2) Develop administrative policies/procedures for management/security and storage of such documentation by service area administration/authority boards.

TASK ASSIGNMENT:

The Operations/User Group Committee should determine what expectations are for user groups in all affected areas. One suggestion would be to query each affected geographic area (e.g. by county/service area) to determine expectations from users for geographic coverage as well as penetration/propagation characteristics.

12.2 FUNDING AND FEES COMMITTEE

COMMITTEE FOCUS

Seek funding sources for all user agencies and explore and adopt, if required, user fee structure.

KEY ISSUES

1. Research grant possibilities.
2. Research funding via Anti-Crime Bill.
3. Check funding sources used by other states that have implemented a statewide system.

4. Prepare cost analysis so we know how much money is needed overall (infrastructure).
5. Obtain roll out schedule from State.
6. What agencies have equipment or site locations that can be used in lieu of user fees.
7. Explore sources for agency sellbacks of existing equipment.
8. Establish user fee schedule.
9. Provide funding information to potential user agencies

ISSUE 1. Research Grant Possibilities

OBJECTIVE: IDENTIFY FUNDING SOURCES

STRATEGIES

1. Find resources to steer us toward funding sources on State and Federal levels.
2. Look at like technologies for funding sources.
3. Locate a specific individual familiar with available grants.

RESOURCES

1. State Legislators
2. Colorado Trust
3. Federal Legislators

ISSUE 2. Research Funding via Anti-Crime Bill

OBJECTIVE:

STRATEGIES

1. Keep informed about passage status.
2. Lobby legislators soliciting support for all aspects which could benefit statewide trunking system.
3. Find out which agencies have lobbyists.

RESOURCES

ISSUE 3. Check funding sources used by other states that have implemented statewide systems.

OBJECTIVE: IDENTIFY FUNDING SOURCES

STRATEGIES

1. Contact vendors who have implemented statewide systems for local resources.
2. Contact APCO 25 Steering Committee for local resource list.

RESOURCES

1. Bob Tolman
2. Motorola and Ericsson GE

ISSUE 4. Prepare cost analysis for infrastructure

STRATEGIES

1. Prepare costing methodologies - may be one or several options.

RESOURCES

1. Mike Borrego's survey
2. Population survey
3. Coverage map survey

ISSUE 5. Obtain implementation schedule from State

STRATEGIES

1. Obtain schedule of implementation.

RESOURCES

1. Mike Borrego

ISSUE 6. What agencies have equipment or site locations that can be used in lieu of user fees.

STRATEGIES

1. Get survey previously done by State regarding what agencies have potentially shared sites.
2. May have to do another survey due to lack of response to State survey.

RESOURCES

1. Mike Borrego
2. APCO

ISSUE 7. Explore sources for agency sellbacks of existing equipment

STRATEGIES

1. Obtain brokerage sources for agencies to sell back existing equipment as a way to offset initial costs.
2. Explore trade-ins with vendors.

RESOURCES

1. Trade periodicals
2. Mike Borrego
3. Motorola and Ericsson GE

ISSUE 8. Establish user fee schedule

STRATEGIES

1. Establish costing methodology after return of surveys

ISSUE 9. Provide funding information to potential user agencies

STRATEGIES

1. Obtain grant information, etc., previously discussed.
2. Compile funding information gathered into packet.
3. Provide packets to potential user agencies.

RESOURCES

1. Colorado Trust

FUNDING AND FEES COMMITTEE SUMMARY REPORT

The funding committee final report identified 4 potential funding sources. Once the actual system cost are well defined the committee can continue with funding and grant possibilities.

1. The Division of Telecommunications should explore the NTIA grants for communications projects and report on the progress.
2. Pursue other grant possibilities... Through the catalog of Domestic Assistance Grants Denver (303-844-3964).
3. Local agencies may be able to receive assistance from the 911 authority board, or local bonds as pursued by each users group for their area.
4. FEMA may have other areas that we can pursue, especially for the state wide backbone structure. The Division of Telecommunications would have to initiate this source. The State Office of Emergency Management, Richard Bardsley (303-273-1619)

In all areas Colorado legislative support is most desirable. Support is needed from the cabinet level, the JBC and local Representatives.

12.3 TECHNICAL COMMITTEE

COMMITTEE FOCUS

VHF and/or 800

KEY ISSUES

1. Enough VHF Frequencies
2. 800 Mountain coverage
3. Identify frequency needs for each area
4. Option needs for multiple Vhf at one site; IM, Noise
5. Stand alone
6. Migration
7. Private (Cencall)

ISSUE 1. Are there private systems already trying to do what State wants to do?

OBJECTIVE: CHECK WITH CENCALL, MOTOROLA, ETC.

STRATEGIES

1. Contact Cencall, Motorola and other large users to keep in touch with what they are doing in this area.
2. Do Feds need to consider this?

RESOURCES

1. Commercial contacts

ISSUE 2. Can we put 20 VHF frequencies at one site location/IM, noise problems, etc.?

OBJECTIVE: DETERMINE POSSIBILITY OF USING 20 VHF CHANNELS AT ONE SITE LOCATION

STRATEGIES

1. Contact cavity combiner manufacturers to see where they are going with Vhf combining techniques. What do they plan with Vhf trunking, refarming?
2. How many Vhf channels are required at each site? If Vhf is only rural, it may not be a problem.

RESOURCES

1. Cavity manufacturers
2. State engineers

ISSUE 3. Will migration be easier to 800 or Vhf or Uhf?

OBJECTIVE: LOOK AT USING EXISTING FREQUENCIES. WILL THIS HAVE AN EFFECT ON MIGRATION?

STRATEGIES

1. Look at migration from State point of view.
2. Look at migration from Federal and Local Government point of view.

RESOURCES

1. State, Local Government

2. New technologies looked at from migration point of view

ISSUE 4. Is 800 coverage in mountains adequate?

OBJECTIVE: DO SIGNAL STRENGTH AND SITE NOISE READINGS IN ALL AREAS OF STATE?

STRATEGIES

1. State test Glenwood.
2. Do site tests in local areas using local help if needed.

RESOURCES

1. Test equipment
2. Manpower
3. Computer mapping of results
4. Vendor or large-user tests that have been already done

ISSUE 5. How many channels needed in each area?

OBJECTIVE: TRY TO START DETERMINING HOW MANY FREQUENCIES/CHANNELS WILL BE REQUIRED IN WHAT AREAS

STRATEGIES

1. Start list of possible users.
2. How many radios per user?
3. How many talk groups?
4. FCC loading requirements

RESOURCES

1. State Engineers
2. Input from local users

ISSUE 6: Is there enough VHF to do entire system?

STRATEGIES

1. Follow part 88.
2. Pair-up all participating VHF frequencies.
3. Look at frequency re-use limitation.
4. Total VHF channels required for system

RESOURCES

1. State engineers
2. Vendor's help
3. FCC Part 88

ISSUE 7. Simulcast vs. Stand alone

TECHNICAL COMMITTEE SUMMARY REPORT

The technical Committee looked at a number of technical issues as it met throughout the year. Because the issues of the FCC rewriting part 90 and the APCO 25 not being resolved, a number of the committee's' issues and concerns could not be addressed at this time. The Committee agrees the State has a big task ahead of them and the following recommendations were given.

1. The State needs to put in an APCO 25 compatible trunked system. Whether it is 800 MHz or VHF still needs to be determined. The technical committee agreed that this system should be on one frequency band only, if at all possible. A two band system would require too much redundancy for roaming vehicles.
2. Great care and planning needs to be done in the area of communication between users of this system and those remaining on conventional frequencies or those on non compatible trunked systems. It was noted that there is a lot of misconceptions as to how users on this system will monitor and talk to users not using this system. Also, some misconceptions as to what backward compatibility means. There are some who believe that a 800 MHz radio, if it is backward compatible will be able to have analog VHF frequencies programmed into it. This needs to be completely explained and clarified with the agencies wanting to participate in the system.
3. The operational committee submitted a want list, that the technical committee went over point by point. The operational committee said these request were "Pie in the sky" requests and they were asked to list any futuristic type of things they would like to see on the system. We believe that the State should put in the best system available at the time the money is appropriated and that future add on or capabilities will be entirely up to the vendors.

If the vendors get enough requests for a certain type of equipment or certain enhancements to the system and if they think they will be able to sell enough units to make it worth their while that the product will become available to the users.

Therefore, we believe this entire list should be kept as a wish list and should be made available to the vendor at the time of their design and engineering stages into this project so that they know what futuristic ideas the users or possible users of this system are looking for.

The State when they consider the proposed system should take into consideration the system architecture, the vendors futuristic expectations for that system, and how easy will be to implement these expectations and wants into the existing system.

The Technical Committee came up with the following items which need to be resolved prior to system design:

These item are in order in which they need to be finished.

1. Identify users, Unit count per are, coverage/building penetration etc., options required and roaming requirements.
2. The information above will give you an idea of frequency pairs required. Then you can determine which bands are feasible to use for the system. The goal here is to have the system within one band if possible.
3. The overlay system should be designed as a wide area system require for the States operation.. The underlying system should be designed for penetration, portable coverage, etc. as required by local agencies. This should be done using simulcast if possible. If this must be done with other frequencies due to overlap. More frequencies will be required.

12.4 STEERING COMMITTEE

COMMITTEE FOCUS

Manage the process of Planning, Promoting, Implementing the digital trunked radio system of the State of Colorado.

KEY ISSUES

1. Monitor APCO and other standards. (Insure tech committee does this.)
2. Review other committee work and provide direction.
3. What is our role to the Division of Telecommunications?
4. How is the system going to be administered: during planning; after implementation?
5. Set time lines.
6. Identify barriers to implementation of project.
7. Ensure equal affordability of system. Who has grant money available? (Funding Committee)
8. Use short term sub-committees to get projects done.
9. Advise Division of Telecommunications on needs of system.

10. Develop long term system advisory team.
11. Define relationship with Division of Telecommunications
12. Recommend establishing Advisory Board

STEERING COMMITTEE OVERSIGHT:

Operational Requirements Subcommittee

1. Practical applications
2. Encryption
3. Network Control
4. Talk groups
5. Coverage

Technical Subcommittee

1. Hardware - equipment, etc.
2. Software - programming, etc.
3. Coverage
4. Frequency band
5. System operations
6. Dispatch service
7. Maintenance support
8. Authority and control
9. System user guidelines

Discipline for non-compliance

Funding/Fees Subcommittee

1. Recommend possible revenue generating mechanism
2. Ballot issues
3. Possible surcharges (DL, Reg., telephone (?) etc.)
4. User fees
5. Grants
6. Conventional funding - State

STEERING COMMITTEE SUMMARY REPORT

The Digital Trunked Radio User Group was established in October 1993. There were four main committees that evolved from the overall group. Those committees are the Steering Committee, the Funding Committee, the Operations Committee and the Technical Committee. Each committee was assigned the

specific task of making recommendations for the overall system design, funding and operations as pertained to the different agencies represented in the groups.

The committees have completed their tasks and submitted their reports (enclosed). Based on the reports and the meetings held, the following recommendations are offered:

It is essential to have a project plan in place including system design, operation, function and most importantly the costs of participation, to assist agencies in making a decision whether to join in the project or to stand alone. It is the consensus of the committees that it will be difficult, if not impossible, to obtain support from other local and federal agencies until these items are accomplished. Once the plan is developed, we recommend the information be distributed to the members of the Digital Trunked Radio Users Group for review and comments. A meeting of the Users Group should then be scheduled to discuss the contents of the plan.

The Division of Telecommunications and Colorado State Patrol should seek funding for a statewide project supported by all state agencies to establish the system backbone and statewide regional communications centers. It is also recommended that a presentation be made to the Governor's cabinet members outlining the overall system proposal and benefits for each individual agency as a statewide telecommunications network. The purpose of the presentation would be to obtain high level support that could be used in individual department lobbying efforts for project funding. It will be difficult to seek alternative funding without a project plan.

Since the possible participation of federal agencies could offer considerable potential economies, as well as having a major impact on the size of the system, the Division of Telecommunications should fully understand the requirements for federal participation. The plan must meet federal concerns including security and control, cost and features, and nationwide interoperability.

Specific questions from the Steering Committee are:

Is the system design incumbent upon the finalization of the APCO 25 standards?

What will it cost? Have specific federal funds been identified as a result of FCC Rule 92-235 - the frequency spectrum re-farming proposal?

What are the benefits for individual agency participation?

What can the steering committee do to facilitate obtaining the needed resources?

It is our final recommendation that the Division of Telecommunications prepare a white paper to contain initial planning, system configuration, proposed schedule of implementation, proposed costs and a structure for the administration of the

system. This white paper should be distributed to all potential participants and thoroughly discussed within the Digital Trunked Radio Users Group.

It is the desire of the Steering Committee to see the work completed by the Digital Trunked User Group be utilized in producing a final product. We are willing to work with you during the legislative process and through community outreach meetings for presentation of the final plan.

12.5 TRUNKING OVERVIEW

DEFINITION AND OVERVIEW

Trunking allows the communications needs of a large number of users to be efficiently met by sharing a small number of trunks (communications paths.) Trunking by definition is the automatic and dynamic allocation of a small number of radio frequencies among many users. The effectiveness of trunking is predicated on two fundamental characteristics of the system user's need for communications:

1) The percentage of time that any individual user requires a trunk is very small.
2) The probability that many users well require a trunk at the same instance is exceedingly small.

Although trunking technology has played an important role in the telephone industry for nearly a century, the application of trunking technology to radio dispatch communications was first accomplished in the late 1970's. This was made possible by two developments:

1) New technologies (large scale integrated circuits and microprocessors) became available to reliably implement more complex systems in a cost effective manner.
2) In response to channel congestion problems, the FCC ruled that large (more than five channels) 800 MHz systems shall be trunked.

The most obvious benefit of a trunked radio system is its increased efficiency - the ability to reduce radio user waiting times. In addition, because trunking technology is computer software driven, it has opened up a number of system management capabilities to the user. In broad terms, trunking allows:

1) The organization of radio users by talkgroups rather than by frequencies;
2) The effect of a private channel per talkgroup no monitoring is necessary;
3) The Flexibility to reorganize and expand the system as the need arises.

The features of a typical trunked radio system are described below. The use of specific characteristics is only to assist in the systems descriptions and may vary among the various systems.

SEQUENCE OF OPERATIONS

A basic trunked system consists of the following:

1. A grouping of transmitter/receiver (T/R) paired channels with one repeater per channel pair;
2. A dedicated control channel which receives radio user service requests and sends responses to service requests;
3. Multi-frequency mobiles, portables and/or control stations with micro-processor controlled logic circuitry; and
4. A system central controller which provides the intelligence to perform channel switching functions.

User groups access the trunked radio system via mobile, portable and/or control station radio equipment. Typical trunking communications is group oriented; one member talks while all others listen. The primary level of organization is the talk group. Multiple talkgroups can be organized into fleets, with a maximum of 4000 talkgroup/fleet combinations supported on a system. In this simple example, there are two talkgroups and a dispatcher position in each of three fleets shown.

In a typical 5 channel system with no communications in progress. All of the mobiles, portables, and control stations are silently monitoring the system control channel.

A typical call sequence proceeds as follows:

1. The dispatcher of fleet 2 wants to talk to members of talkgroup A. He depresses his push-to-talk button which automatically sends a burst of data to the central controller via the control channel. This data constitutes a request for a voice channel.
2. The system central controller reviews the status of all the voice channels and selects an unused channel, channel #2 in this case. The central controller then sends an outbound burst of data, via the control channel, directing all fleet 2, talk group A radios over to channel #2. All of the idle (not assigned to a voice channel) radio units receive the outbound instructions.
3. Only radios in talkgroup A of fleet 2 respond to the outbound instructions and automatically switch to channel #2. Radios not associated with talkgroup A will disregard the instructions and remain on the control channel. The individual who initiated the call will then have his transmitter automatically activated and will be able to communicate with other members of the talk group. Any radios in the talkgroup otherwise engaged or not turned on to the system when the talkgroup call is initiated will be signaled and automatically directed to the talkgroup call in progress once their call ends, or they turn on to the system.

The total elapsed time from press of the PTT by the initiating party until the beginning of the message is heard by the receiving talkgroup members is typically much less than ½ second for a single site system.

Under normal operations, no two user groups making a talkgroup call would ever be assigned the same voice channel at the same time, eliminating the need for one group to monitor another. Note that each talk group has, in effect, a private channel for the duration of its messages.

In the event that dispatcher 2 wants to talk to all members of his organization, A trunked system also allows a fleetwide call (announcement call) to be made. The call sequence is similar to that of the talkgroup call. However, in this case, all radios in talkgroup A and talk group B of fleet 2 respond to the outbound instructions to move over to the assigned voice channel.

A mobile or portable initiated call sequence is identical to that of the dispatcher. A summary of the call sequence is as follows.

- Radios synchronized to the control channel (silently monitoring.)
- Originating radio operator presses PTT.
- Inbound channel request is sent to the system central controller.
- Outbound channel assignment is broadcast to all idle radios on the system.
- All radios in the talkgroup called automatically switch to the assigned voice channel.
- Originating radio transmitter is automatically activated.
- Call messages are exchanged.
- Call is completed.
- Radios return to monitoring control channel.
- Voice channel available for reassignment.

SIGNALING

The trunked radio system is comprised of many types of equipment: The system central controller, base station repeaters, mobile and portable radios, and control stations. A data communications network ties these entities together to achieve efficient systems operation.

Most data signaling takes place over the control channel. Requests for service are sent from system users to the system central controller over the control channel. Similarly, channel assignments and commands from the central controller are sent to individual radio units over the control channel. Information is assembled into a sophisticated coding format, with sufficient error detection and correction capabilities to assure system reliability.

Not all trunked radio systems use a dedicated control channel which is always available to receive data packets. However, there are several advantages of having one; it:

1. Increases reliability in accessing the system, because signaling attempts are repeated automatically (Automatic Retry).
2. Increases system efficiency and reduces user wait times during the busy periods.
3. Can direct a user, who was previously engaged, to a talkgroup conversation already in progress (Continuous Assignment Updating).
4. Permits orderly processing of busy period backlogged calls on a first in first out basis (Queuing).
5. Performs many non-voice system features such as dynamic regrouping, call alert, and status/message.
6. Allows maximum data throughput; no time is spent on mobile scanning.

Additional low frequency, low deviation signaling occurs over the voice channels. Continuous tone, sub-audible signals are transmitted by mobiles and portables, and digital sub-audible signals are transmitted from base to mobile. These signals are necessary to provide misdirected radio protection, priority monitor and call update information.

SYSTEM CAPACITY AND RESPONSE

Although busy periods are of short duration, trunked systems must be designed to accommodate peak hour message traffic. System performance characteristics are therefore stated in relation to busy hour (worst case) periods. This section will address system capacity and performance on typical public safety and private industrial systems. Statistical data derived by monitoring air time usage of public safety and commercial system users is provided as a tool for estimating the capacity of new systems.

Keep in mind that there is no simple rule in determining loading requirements. The following graphs are provided to serve as a reference tool and illustrate the trade offs between system loading, number of channels, and estimated access times. When planning system capacity, take into consideration the set of circumstances which produced the statistics below and make adjustments accordingly. Variables which influence system performance include: How users use their system, the number of talk groups on the system (many talkgroups increase the chance of simultaneous usage and delay): the type of users (dog catchers will have very different call patterns than police squads and from the maintenance crew at an oil refinery); use of individual calling capabilities (Private Conversation, telephone interconnect, etc.); and how priority levels are assigned to groups on the system. Access times are also affected by the type of system; single site, Simulcast or Automatic Multiple Site Select.

System access time includes time elapsed between the instant the radio operator presses his PTT and completion of the channel assignment. Access times could be lengthened by inbound or outbound signaling delays or any voice channel blocking. The public safety loading statistics represent a system with: More talkgroups than channels (approximately three times as many), equal priority for all users, minimal individual calling, an average of 10 second call lengths, and 3 calls per unit (typical of police operations) during the busy hour.

System usage levels on most industrial systems fall between those on public safety and commercial systems, with public safety being the worst case and commercial Specialized Mobile Radio (SMR) the best. SMR loading statistics assume equal priority for all users, 18 second call lengths, 7.6 second hold times, and 1 message per unit per hour.

Although system loading is planned with the worst case in mind, access times are typically far faster during normal (non-busy) operation.

FLEETMAPPING

The fleetmapping process presents alternatives for configuring talkgroups on a trunked radio system. The fleetmap is the software "code" stored in the central controller memory which holds the talkgroup and individual identities (personalities) or each radio on the system.

In trunked systems, there are trade-offs between the number of talkgroups and individual IDs which can be supported as represented by a fleet size code. (Fleet refers to a grouping of radio IDs. How talkgroups are grouped into fleets will affect the operation of certain features.) With trunked systems, fleet boundaries are not necessary and there are no restrictions on talkgroup and individual ID combinations up to a limit of 48,000 total IDs and 4000 (2000 if priority monitor feature is used on the system) talkgroups total per system.

In either case, there will be a trade-off between the number of talkgroups and the efficiency of channel usage. A greater number of talkgroups may result in greater utilization of channel resources. In addition, in dispatch oriented applications (e.g. public safety), the number of talkgroups formed should not exceed the capabilities of the dispatchers. Typically, one dispatcher can handle up to 8 talkgroups.

Regardless of the type of system, the fleetmapping process begins with identifying:

- Who needs to talk to whom on the system and how individuals should be grouped into talkgroups, and
- Expansion needs; how many radios will be added to the system.

II. TRUNKING BENEFITS & FEATURES

USER CONVENIENCE FEATURES

There are many benefits and features offered in a trunked radio system. This section provides a functional description of each feature and differentiates between basic trunking features, inherent in all trunked systems and advanced trunked features.

There are several conveniences built into a trunked radio system which are not available on conventional systems. The following features simplify radio operations for the user and are inherent to various degrees in all trunked systems.

Busy Queuing and Callback

Although trunked systems are considerably more efficient than conventional systems, there may still be times when all of the voice channels are busy or when channels with special call processing capabilities (e.g. telephone interconnect) are busy. If a radio user depresses the PTT while all the system channels are in use, he will hear a series of busy tones until a channel is assigned or he releases the PTT. (A continuous tone will be heard when the PTT is depressed and the radio is out of range or the system is out of service.)

For convenience, any users requesting system access during a busy period will be put in a queue. On a FIFO (first in first out) basis, when a channel does become available, the system central controller will notify the first mobile by "calling him back". A talk permit tone heard on the operator's radio alerts him of the call back. This feature allows the radio user to put the microphone down in a busy situation and wait for the callback, instead of continually keying in an effort to gain channel access.

Multiple Priority Levels

In addition to giving priority to recent users, trunked systems provide multiple levels of priority to allow system access to the most critical users during busy periods. Users and groups may be assigned a particular priority level and in the event of a busy, channel requests are processed according to priority on a first come first served basis. Assignment of priority levels can be controlled by the system manager via a System Manager Terminal or through SIMS (with the proper software option). One level of priority (tactical) can be assigned to a talk group via the console.

Eight levels of priority are available on a trunked system. An emergency call (described later) will always take the highest priority on a trunked system.

Automatic Retry

Automatic Retry is a feature built into trunked systems to ensure system access and eliminate the need for a radio user to rekey or remain keyed in an effort to gain a channel. When the radio operator pushes his PTT, the radio sends a burst of data to the system central controller via the system control channel to request a voice channel. To ensure that the request gets through in the event of weak signal levels or interference, the radio unit will automatically continue to send a channel request until the request is acknowledged by the central controller, or until approximately 4 seconds have passed. Usually, because of effective system throughput, the acknowledgment takes place on the first try. Automatic retries are random to minimize the possibility of contention on the first try.

Recent User Priority

To ensure uninterrupted communications, recent user priority has been designed into trunked systems. This assures that users who have previously been assigned a voice channel will receive priority over other system users of the same priority. Recent user status ends if a PTT is not activated within 10 seconds of the channel assignment ending.

Ergonomics

Trunked radios have been designed to be user friendly. Depending on the trunked radio model various display options, keypad controls and indicator tones are provided to make the radio easy to use.

CALLING/OPERATING CAPABILITIES

Trunked radio systems offer the radio user a variety of calling capabilities to suit a variety of communications needs. The following types of calls are available as features or options on the radios and/or console.

Talkgroup Call

The talkgroup is the primary level of organization for communications on a trunked radio system. Radios assigned to a given talkgroup will be provided with “talkgroup call” and will under normal operation, only be able to communicate with other members of the same talkgroup. This provides the effect of a private channel down to the talkgroup level.

The capability of allowing radio users of the same fleet to selectively move between talkgroups of that fleet is optionally provided on the radio unit with a manual switch or keyboard. A trunked system supervisor can also change a radio user’s talkgroup assignment via the dynamic regrouping option available on TRUNKED trunking terminals.

Fleet Call

Fleet calls can be made on trunked systems. It allows simultaneous communications to all members of the talkgroups of a fleet, utilizing a single channel resource. Fleet calls can only be made from a radio unit with the capability programmed into its code plug and which is enabled in the central controller database.

Fleet calling capability should be assigned with care because of the air time it requires to set up this kind of call. When a fleet call is placed, the user must wait for others in his fleet engaged in conversation to dekey their mics before the fleet call can begin. Others in the fleet will get a busy signal if they try to make a call after a fleet call has been initiated but has not yet been granted a channel. Calls initiated during this period will not be placed in a queue and must be reinitiated after the fleet call. Those involved in telephone interconnect calls are not affected by a fleet call. Once they complete their telephone call, they will automatically join the fleet call in progress.

A fleet call is transmission trunked (described in System Design Flexibility). Other radios in the fleet will not be able to transmit until the fleet call ends. After the fleetwide announcement has been made and the user dekeys, the fleet will return to normal dispatch calling operation.

Multi-Group Call

A multi-group call is used to describe a call involving multiple talkgroups at the same time and refers to a fleetwide call or an announcement call on trunked systems. Multi-group calls can be initiated by a dispatcher or a field radio user. The groups to be addressed in a multi-group call are pre-programmed into the radio unit or dispatch equipment.

Announcement Call

An announcement call is the feature used to make a multi-group call on trunked systems. This feature can be optioned to operate similarly to a fleet call (the caller must wait for other members of the fleet to dekey before he can transmit), or with an interrupt, when a user initiates a multi-group call, his call will immediately interrupt other conversations in progress without waiting for other users to dekey. However, those radio users who are transmitting on a voice channel will not hear the announcement call until they dekey. They will then join the announcement call if it is still in progress.

System Call

A system wide call operates similarly to a fleet call and has similar ramifications regards to air time usage. System calls can only be placed from a console. When a system call has been placed, the user must wait for all users on the system to dekey and join the system call. All other users will get a busy if they try to make a call during this period. These call attempts will not be queued and

must be reinitiated after the system call is completed. Users engaged in telephone interconnect calls will not be aware of the system call will not be aware of the system call until their phone call is completed, at which time they will join the system call in progress. The system call is transmission trunked. After the system wide announcement is completed and the user dekeys, the system will return to normal dispatch operations.

Dual Mode Operation

Dual mode capability is a standard feature of most trunked radios. Conventional repeaters are often designed into a trunked system to extend coverage to fringe areas. In order for a user to communicate in the conventional mode, his radio unit must be programmed with a conventional frequency. trunked radios are equipped with a "smart" PTT. While in the conventional mode, if the channel is busy when the radio user presses his PTT, the radio will not transmit but will monitor the channel. To transmit the user must press the PTT a second time.

Repeater Talkaround

Repeater talkaround gives a radio user the capability to talk "radio to radio" when out of range of the trunked radio infrastructure, or when there is a special need to directly talk " radio to radio", e.g. telephone company cable pullers. Talkaround is an option programmed into the radio. It utilizes a conventional channel that is not a part of the trunked system.

To achieve talkaround, the radio user who wishes to initiate a call switches his radio over to the talkaround mode. At this time, his radio can transmit on the same frequency at which the radio he is calling receives messages, and therefore bypasses the trunked system. The user called must be instructed, or by a pre-established procedure, must also switch over to the talkaround mode in order to respond to the call.

Talkgroup Merge

Talkgroup merge is a dispatch function in trunked systems which allows multiple talkgroups to be merged together to talk on one voice channel. It is a function that only a trunked console can carry out. Efficiency is a major benefit of this feature since only one channel is used. Also, once it is set up, merging occurs very quickly. Two types of talkgroup merge are available, multi-select and patch. With multi-select, the merge is activated when the dispatcher is transmitting. Users in the merged group automatically return to their original talkgroups at the end of the conversations. With patch, users remain in the patched group until the dispatcher manually ungroups them. Any user transmitting is heard by all radio users in the patch group.

Roaming

Direct access roaming is the capability for a radio user to move about a large geographic area and be able to switch to different systems to meet his communications needs at different locations. It is a capability inherent in all trunked systems. The individual radio must be programmed to directly access all systems he wishes to roam to as well as be enabled on those systems by their system managers. When the user moves out of range of one system and into range of another, he must manually switch over to the new system by turning a selector knob or pressing a keypad (depending on the radio). The ability to automatically switch systems is provided with System Search & Lock.

12.6 GLOSSARY OF TERMS AND ACRONYMS

800 Megahertz - The frequency band where public safety trunked systems operate. The channels between 806 and 869 Megahertz.

ADDRESS: Actual id given to any radio unit. combination of system, agency, fleet, sub-fleet, and individual.

AGENCY: First level of structure with the system. Examples include fire dept. or police dept.

ALIAS - Proper names instead of Unit ID, Subfleet of Fleet characters.

ALL CALL: Console feature which allows dispatcher or supervisor to communicate to all system radios at one time. Used for major traumas or emergencies.

AMSS - Automatic Multiple Site Select. A wide area coverage trunking system configuration which makes use of channel reuse to extend the coverage area of the single site system.

ANALOG - The varying frequency and amplitude of sounds or voice with no alterations or changes.

ANNOUNCEMENT GROUP - This is a form of fleet-wide call, with the announcement group consisting of any number of talk groups on the system; this may be message or transmission trunked; there is talkback capability possible also.

APCO - Associated Public-Safety Communications Officials Inc. An International professional organization with over 11,000 members from federal, state, local government and equipment vendors in all aspects of public safety communications.

AUTOMATIC VEHICULAR LOCATION (AVL): Subsystem which interfaces with radio system to communicate actual location of vehicle in a premapped geographic grid via RF.

BAUD: The rate at which data is transmitted.

BSI - Base Station Identifier. The BSI, which usually operates at the lowest frequency, is the Morse code identification that automatically occurs at regular intervals from one of the Trunked repeaters.

CAD - Computer-Aided Dispatch. The current convention in public safety radio communications dictates use of computers in order to answer requests for emergency service more efficiently.

CAI -.Common Air Interface. A part of the APCO Project 25 standards that define the basic structure for the equipment including, channel access method, data rate, spectrum efficiency and vocoder.

CALL QUEUING: When all channels on the system are busy, the call request is held in a first-in-first-out queue. The caller and all members of the groups are notified that a call request has been queued. Upon channel assignment, the caller is alerted and is allowed to proceed with push-to-talk (PTT).

CALL RETRY: Feature which is used by radio when unsuccessful in acquiring a requested channel. The radio will continue to request a channel until successful or has attempted 8 times. This is not apparent to the radio operator.

CCIC - Colorado Crime Information Computer

CHANNEL ACCESS TIME: The time between depression of the PTT switch by the radio operator and the unsquelching of audio at the receiving radios. Fast access time contributes to system efficiency.

CHANNEL DROP TIME: The time between radio un-key and when the channel is actually available for another call. Fast drop time contributes to system efficiency.

CONNECT TONE - The Connect Tone is a sub-audible (below 300 Hz) tone that is transmitted by a mobile or portable to the system, any time the unit is keyed. The specific frequency of this tone is determined by the program of the mobile or portable.

CONSOLE: Control center in dispatch center. Unit is microprocessor controlled and is tailored to dispatcher needs. Single and multi configurations.

CONTROL CHANNEL - This is the channel of the system upon which outbound system updates and responses to service requests occurs; and it is the conduit for all interactions to gain access to trunking resources by radio units.

CONVENTIONAL - Assigning a specific channel for a specific dedicated use. A non-trunked channel.

DATA TERMINALS: Terminals which support the transmission of data via RF. Include a display and keyboard..

DIGITAL - Encoding analog information into a code made up of 0's and 1's

DIGITIZATION: The conversion of continuous analog wave form to binary digital data. See vocoding.

DISCONNECT TONE - The sub-audible tone that is generated by a mobile or portable and transmitted to the Trunked system upon de-keying is called a Disconnect Tone.

DISPATCH: Normal operating mode of the system. Communications are limited to single group and dispatcher. All in group hear only own group and dispatcher is communicating to single group.

DYNAMIC REGROUPING - Over-the-air programming of field units. Multiple talk groups can be added to a radio unit while the radio is active in the field. Optionally, field units can be forced to communicate on designated talk groups.

EMERGENCY: Emergency switches are available on every radio. When depressed, the first available channel is assigned to the user—highest priority is assigned to an emergency user. Emergency indicators are lit on user group radios.

ENCRYPTION - Digitalization and scrambling of the voice signal to prevent unauthorized monitoring of the message over the airwaves.

ETHERNET - A Local Area Network (LAN) of IBM PC's used in some TRUNKED system configurations having the SIMS option.

FAIL SAFE: System feature which allows the system to continue to operate and trunk in channels or site controller fail to operate properly.

FAIL SOFT - This is an automatic fall back mode of communication offered in the event that the trunking central controller fails, all four control channels fail, or failure of all voice channels. The repeaters independently enter the failsoft mode when the central no longer controls them; this is a form of carrier squelch community repeater operation.

FAULT TOLERANT ARCHITECTURE: A design and implementation philosophy that permits a system to continue operating in the event of failure of major components

FCC - Federal Communications Commission

FDMA - Frequency Division Multiple Access. A method for improving spectrum efficiency by splitting an existing channel into 2 or more separate channels

FIFO - First-In, First-Out. Queue. In the case of a busy Trunked system, individual requests for service will be handled in a FIFO manner.

FIRMWARE - Memory-type IC's, such as EEPROM's, which are programmed to contain software-like instructions are commonly referred to as Firmware.

FLEET - A grouping of trunking units with some commonality. Second level within system structure. Examples: traffic control or precinct within police dept.

FWC - Fleet Wide Call.

GROUP: combination of radio users which have been linked together for communications. May be system, agency, fleet, or subfleet. May be defined from the system manager position or dynamically reconfigured as needed.

GROUP PRIVACY: Groups do not have the ability to listen to groups other than their own. The result is privacy.

GROUP REGROUP - This is the mechanism to temporarily join dissimilar trunking talk-groups for calls upon a single channel resource.

HANG TIME: The time a channel remains keyed after release of the C by transmitter. GE allows adjustable hang time from 0 to 55 seconds.

IDENTIFICATION (ID): A number associated with field radios, the unit id, that uniquely identifies the radio. This number, referred to as logical id, is automatically sent anytime the radio transmits.

IMBE - Improved Multi-Band Excitation. A method use to change an analog signal to a digital signal.

INDIVIDUAL: Lowest level of system structure. Example: car 54, 3rd precinct, traffic control, police dept. Each individual has a unique id.

INDIVIDUAL CALL OR I-CALL: a private call on a trunked system from one field radio to another field radio or from the dispatcher to or from a field radio.

INTERCONNECT - Interconnect is sometimes referred to as CIT or Passport, and is an optional telephone interconnect to a Trunked system. Mobile and portable units that have this option have independent and automatic telephone call capability.

LOG IN: a transmission from a field radio that occurs automatically, informing the system about the active status, talk group selection and specific operating site, if part of a multisite network.

MESSAGE TRUNKING: The working channel remains assigned to a call for the duration of the group transmission. When the caller unkeys, the channel remains active until the group conversation is completed or the channels hang time is reached. The channel, is not available for reassignment until the group conversation is done or the channel times out.

MULTISITE: A network of multiple sites in a systems. Each system networked may have a different number of working channels. To prevent RF interference, adjacent systems do not use the same RF frequencies.

MUX - This word is a shortened version of multiplex.

NCIC - National Crime Information Computer

NETWORK: An intelligent wide area network links systems. Users may roam from one system to another while the network controller, either a multisite controller (msc) or integrated multisite and console (imc) controller, automatically tracks location and status.

NETWORK MANAGEMENT SYSTEM - Hardware and software used to control, monitor and report the system functions and operations.

NPSPAC: National public safety planning advisory committee that developed & proposed a plan for use of 821-824 and 866-869 MHz portion of band. Included in plan is new channelization scheme.

PATCH - This is a form of group regrouping in which the joined groups are allowed to carry on normal message trunking operations between and among all the separate member groups of the call, upon a single channel resource. A feature which allows a console operator to connect a mobile group to a

conventional group or another system. It also allows connection of a group to telephone lines.

PERSONALITY PROM - A Programmable Read Only Memory chip which stores the radio's individual digital ID and other special function firmware that gives it it's own unique identity.

PRIME SITE - This term applies to the primary equipment site of a Trunked Simulcast system where all Simulcast audio processing occurs. RF channel resource management also takes place here; the Central Site Controller (CSC) in the Prime Site controls the Remote Site Controller (RESC) in the Remote Site with a data link message which is usually sent via microwave.

PRIORITY: Preassigned levels (up to 8) which determine the order in which users are assigned channels on a system. Emergency, if used, is the highest level of priority.

PRIORITY SCAN: Operation is determined by mode of operation. In conventional mode, system operates by sampling channels for activity and opening squelch to receive messages. In trunked mode, the radio receives all groups for which it has been programmed for scan (up to 50).

PTT - This acronym is short for "Push To Talk".

PTT-ID - Push to talk identification. This is an optional feature which allows a SIMS or TIP user to view the identity of callers when they press their PTT.

REMOTE SITE - In a Simulcast system, the Remote Site repeater is configured the same as that of the Prime Site. The main difference between Prime and Remote Sites is the fact that the repeater site is slaved to the Prime Site.

SELECT ENABLE/DISABLE - This is a feature to restrict the movement of a subscriber unit from the assigned dynamic identity; if the unit has been select disabled, the user of the subscriber unit will not be able to change to another identity position until the reprogramming or select disable has been canceled.

SELECTIVE (RADIO) INHIBIT - An important feature to public safety users which allows a SIMS operator to instantly and effectively "put to sleep" a mobile or portable unit in the field. Misplaced or stolen radios, over which sensitive communications could be heard, can be effectively silenced permanently by the SIMS operator. The target radio must be turned on and within system range in order for this feature to be effective.

SIMS - System Information Management System. SIMS is an optional Local Area Network (LAN) of PC's that can observe Push-to-Talk ID's, Dynamically Regroup radios, Selectively Inhibit, radios and perform other functions depending on options on the system.

SIMUL-SELECT: A feature available to console dispatcher. Two or more groups are simultaneously selected for the same transmission from the dispatcher—but remain separate groups. Response from radio users is by group and only members of each unique group are able to hear the response.

SIMULCAST - A wide area coverage system configuration which makes use of simultaneous transmission of the same information upon the same frequencies throughout a large coverage area; parameters of the transmitted information is matched for each repeater of a given frequency.

SITE CONTROLLER: Computer system located at the site which controls all system activity, channel assignments, logging, supports test and alarm unit, and communicates to system manager via dedicated line or dial up modem.

SMR: Special Mobile Radio. FCC classification used by entrepreneurial operators of 800 MHz trunked systems that service the business and industrial markets.

SMT - System Manager's Terminal. A hard-copy terminal connected either directly to its dedicated RS-232 port at the rear of the controller, or remotely via data modems. The SMT can be used to diagnose system problems at a remote location and to change system parameters such as "repeater hold time".

STANDBY CENTRAL CONTROLLER - A redundant Central Controller. The Standby Central Controller can automatically take control over the Trunked system in the event of a Main Central Controller failure.

STATUS MESSAGES: Use in CAD system to communicate without voice to users or dispatcher.

STORM PLAN - This contingency plan is used by Trunked systems for special situations, like natural disasters. This feature allows the user to preset emergency procedures, such as dynamic regrouping, dynamic failsoft, and selector disable to several radios. By having this plan available to the SIMS operator, emergency situations are more likely to be handled in a quicker and more logical manner.

SUBFLEET - A Subfleet is a subgrouping of radio users with some commonality. Subfleet activity is not heard by other subfleets. Third level in system hierarchy. Example: 3rd precinct in traffic control of police dept.

SUPERGROUP - This is the talkgroup which all the member groups of a group regrouping are joined in and use as their new common trunking talkgroup.

SUPER REGROUP - This is the mechanism to temporarily join dissimilar trunking talk-groups for calls upon a single channel resource.

SYNTHESIZER - A Trunked Simulcast system requires the use of special synthesizers within each of the repeaters. The synthesizers generate the repeater intermediate frequency with the same accuracy and stability as the Efratom rubidium standard which is connected to them.

SYSTEM ID - This is the special identification upon the control channel to identify the particular trunking system using this control channel; this is used by the subscriber units to verify they are operating upon the correct trunking system; it is sent about every 3 seconds on the control channel.

SYSTEM MANAGER: Computer used for system configuration, dynamic reconfiguration, down load of data from site, analysis of logging information, and other management tasks.

SYSTEM MANAGER PORT - The RS232 communication port on the Central Controller. In a system with SIMS, this port is connected to the System Manager Interface computer.

SYSTEM WATCH - A diagnostic tool used to monitor system activity, providing real time display of all call activity as it occurs.

TALK-AROUND - In a normal trunked system all communications uses a repeater to extend the range of the radio. Talk-around by-passes the repeater and talks directly to another unit. Units in the talk-around mode are operating in a conventional mode.

TDMA - Time Division Multiple Access. A method for improving spectrum efficiency an existing channel by allocating specific time slots to each user.

TALKGROUP - A talkgroup is the primary level of organization of users on a trunked radio system. It is akin to a subfleet on a type one system. Talkgroup activity is not heard by other talk groups.

TRAFFIC LOGGING: A function performed by the site controller. Records each transmission id and group as well as time of day and duration. Is sent to system manager for data management.

TRANSMISSION TRUNKING: The working channel remains assigned to a call for the duration of the caller's transmission. When the caller unkeys, the system immediately de-allocates the channel, making it available for reassignment. Equivalent to a zero-second hang time, transmission trunking increases call throughput, resulting in fewer queued calls.

TRUNKING - The sharing of a number of talk paths among many users. A method by which multiple channels are accessed for user needs. Channel assignments are more efficient than systems where channel access is limited to a single channel or require manual user channel switching

UHF - Ultra High Frequency. The frequencies between 450 and 470 Megahertz

UNIT ID: Unique id which has been assigned to radio. Id is transmitted at beginning and end of each transmission and is logged by the site controller.

UPS - Uninterruptible Power Supply.

VHF - Very High Frequency. The Frequencies between 150 and 174 Megahertz.

VOCODER - A electronic device used to convert analog voice signals to a digital signal.

VOTING: The process by which geographically separated receivers pass their received signals to a common point at which the signals are "voted" and only the best signal is passed on for use.

VOX - Voice Operated Transmit.

VOICE CHANNEL - In a Trunked system, a Voice Channel is an RF channel that is an available voice communication channel resource. For example, a ten-channel Trunked system has one Control Channel and nine voice channels.

WORKING CHANNEL: All repeater channels except the single control channel operate as working channels. Radios communicate in all modes, analog voice, digital voice or digital data, via a working channel.

12.7 SYSTEM MAPS